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Mental Health Prevalence and Biofeedback Intervention for Student- Athletes

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Dedication

To my family, thank you for always supporting and encouraging me to pursue my dreams. Mom and Dad, your unconditional love and examples of hard work have taught me to work hard for everything I have and will accomplish. I would not be where I am today without your love, support, and encouragement. Tabitha, Rebecca, and Ericka, thank you for always encouraging me to keep going, even when you did not understand what was going on. Thank you for motivating me to keep up with my mental and physical health with the stress of this dissertation, graduate school, and navigating the troubles of life.

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Abstract

Mental health in student-athletes has been a subject of discussion in the recent past. Historically, student-athletes have been thought to be immune to mental health disorders. Researchers have examined the prevalence of common mental health illnesses such as depression and anxiety and through the previous efforts, and it has been determined student-athletes are at nearly the same risk as regular college students. Even with increased attention to mental health disorders, prevention programs designed to educate student-athletes, coaches, and athletic trainers, the prevalence rates of depression and anxiety in student-athletes have not improved. Therefore, the purpose of these papers was to examine the prevalence rates for depression, anxiety, and low self-esteem across student-athletes by sex, academic status, and sport type. Second, was to examine the effects of a four-week biofeedback intervention on psychological and performance variables. When examining the prevalence of depression and anxiety in student-athletes, the study found an overall prevalence rate of 22.3% for depression and 12.5% for anxiety. Results from the four-week biofeedback intervention indicates no improvement for coherence, psychological or performance variables; however, the student-athlete participants reported positive benefits and effects from the intervention. While our pilot study was not statistically significant for improvement with psychological or performance variables, the student-athletes reported positive benefits from the intervention, indicating a biofeedback intervention could be beneficial for participants. The prevalence results illustrate the signs and symptoms of depression and anxiety are still evident for student-

athletes and future research efforts should continue to create mental health screenings and interventions to address these signs and symptoms.

Table of Contents

List of Tables

List of Figures

Chapter 1

Overall Introduction

Throughout the United States, 1 in 5 adults experiences a mental disorder, with over 40 million adults experiencing a mental disorder each year. The most common mental disorders experienced are anxiety and depressive disorders.[1] These numbers include but are not limited to college students and reactions to their stresses and responsibilities. College students above the age of 18 may be at a higher risk for developing mental health disorders due to high stress, negative life events, or significant life changes. Student-athletes also experience many of the same opportunities as general college students. They are responsible for maintaining academic and sport requirements while holding high standards held by their coaches, teammates, and family members. Often, student-athletes are assumed to be a generally healthy population and potentially immune to mental health disorders. However, recent research has indicated that student-athletes experience a prevalence of 15.6-33.2%[2-7] for experiencing depression and another third experiencing preseason anxiety.[3,8-10] An examination of prevalence in student-athletes across numerous sport types is warranted to update the current research and identify potential risk factors specific to student-athletes.

With a rise in the prevalence of suicide and mental health disorders in student-athletes, the National Collegiate Athletic Association (NCAA) has taken steps to recognize the importance of mental health and wellness for student-athletes. In 2016, the NCAA's Sport Science Institute published its Mental Health Best Practices document for

institutions to use as a resource for mental health and well-being.[11] In addition, research is calling for prevention and intervention programs to help mitigate signs and symptoms of mental health disorders. Currently, the focus is on prevention programs through education and educational materials (e.g., websites, interactive web-based mental health literacy programs); however, these do not include interventions geared to reduce depressive or anxious symptoms experienced by student-athletes.[12]

Biofeedback is a well-known modality in which individuals can visualize physiological measurements (e.g., muscle function, skin temperature, cardiovascular activity).[13] Through biofeedback, individuals gain control of their physiological functions and increase awareness of their thoughts and emotions. The HeartMath Institute has extended research on the effect of heart activity on brain function by developing heart rate variability (HRV) biofeedback modalities such as EmWave and Inner Balance.[14] Inner Balance technologies allow individuals to visualize their HRV in real time to train individuals to recognize heart rate rhythms and implement trainings into daily life. The EmWave technology has been previously used and researched in numerous populations, including but not limited to college nursing students and general college students for stress and anxiety.[15-17] Within these studies, it was found that the use of biofeedback devices and the techniques learned decreased anxiety and maintained stress levels throughout the intervention. EmWave technology has also been used within the student-athlete population and primarily geared toward sports performance.[18-20] To date, research has not focused on the mental health of student-athletes as a primary focus for intervention benefits. Previous studies have eluded to a reduction in anxiety symptoms and it has been suggested the intervention may help with increasing sleep quality and decreasing the symptoms of

depression and stress. Given the prevalence of depression among collegiate student-athletes ranging between 15 and 30%,[2-7] this study aimed to first examine the rates relative to these norms and by background variables of sex, academic status and sport type. Second, based on these findings to determine if a 4-week heart rate biofeedback training intervention on performance and psychological outcomes in current student-athletes would be beneficial for varying sport types (i.e., endurance, ball, power).

References

1. National Alliance on Mental Illness; Depression. https://www.nami.org/Learn-More/Mental-Health-Conditions/Depression. Published 2015. Updated August 2017. Accessed January 30, 2019, 2019.
2. Proctor SL, Boan-Lenzo C. Prevalence of depressive symptoms in male intercollegiate student-athletes and nonathletes. *J Clin Sport Psychol.* 2010;4(3):204-220.
3. Yang J, Peek-Asa C, Corlette J, Cheng G, Foster D, Albright J. Prevalence of and risk factors associated with symptoms of depression in competitive collegiate student athletes. *Clin J Sport Med.* 2007;17(6):481-487.
4. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.
5. Wolanin A, Hong E, Marks D, Panchoo K, Gross M. Prevalence of clinically elevated depressive symptoms in college athletes and differences by gender and sport. *Br J Sports Med.* 2016;50(3):167-171.
6. Martignetti A, Arthur-Cameselle J, Keeler L, Chalmers G. The relationship between burnout and depression in intercollegiate athletes: An examination of

gender and sport-type. *Journal for the Study of Sports and Athletes in Education.* 2020;14(2):100-122.

7. Pluhar E, McCracken C, Griffith KL, Christino MA, Sugimoto D, Meehan WP, 3rd. Team sport athletes may be less likely to suffer anxiety or depression than individual sport athletes. *J Sci Med Sport.* 2019;18(3):490-496.

8. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.

9. Wolanin A, Hong E, Marks D, Panchoo K, Gross M. Prevalence of clinically elevated depressive symptoms in college athletes and differences by gender and sport. *Br J Sports Med.* 2016;50(3):167-171.

10. Li H, Moreland JJ, Peek-Asa C, Yang J. Preseason anxiety and depressive symptoms and prospective injury risk in collegiate athletes. *Am J Sports Med.* 2017;45(9):2148-2155.

11. Institute NSS. Mental health best practices: Inter-association consensus document: best practices for understanding and supporting student-athlete mental wellness. 2016.

12. Breslin G, Shannon S, Haughey T, Donnelly P, Leavey G. A systematic review of interventions to increase awareness of mental health and well-being in athletes, coaches and officials. *Systematic reviews.* 2017;6(1):177.

13. Frank DL, Khorshid L, Kiffer JF, Moravec CS, McKee MG. Biofeedback in medicine: who, when, why and how? *Ment Health Fam Med.* 2010;7(2):85-91.

14. The Science of HeartMath. HeartMath. www.heartmath.com. Accessed2019.

15. Ratanasiripong P, Ratanasiripong N, Kathalae D. Biofeedback Intervention for Stress and Anxiety among Nursing Students: A Randomized Controlled Trial. *ISRN nursing.* 2012;2012:827972.

16. Ratanasiripong P, Sverduk K, Prince J, Hayashino D. Biofeedback and counseling for stress and anxiety among college students. *Journal of College Student Development.* 2012;53(5):742-749.

17. Whited A, Larkin KT, Whited M. Effectiveness of emWave biofeedback in improving heart rate variability reactivity to and recovery from stress. *Applied psychophysiology and biofeedback.* 2014;39(2):75-88.

18. Dziembowska I, Izdebski P, Rasmus A, Brudny J, Grzelczak M, Cysewski P. Effects of heart rate variability biofeedback on EEG alpha asymmetry and anxiety symptoms in male athletes: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(2):141-150.

19. Tanis CJ. Performance enhancement and stress reduction using biofeedback with women collegiate volleyball players. *Athletic Insight: The Online Journal of Sport Psychology.* 2012;4(2):127-140.

20. Rijken NH, Soer R, de Maar E, et al. Increasing performance of professional soccer players and elite track and field athletes with peak performance training and biofeedback: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(4):421-430.

Chapter 2

Examination of Depression, Anxiety, and Self-Esteem in Collegiate Student-Athletes[1]

[1]Samantha R. Weber; Toni M. Torres-McGehee; Zachary Winkelmann; Eva Monsma; Shawn Arent. To be submitted to *J AM Coll Health.* (in preparation).

Abstract

Objective: To examine the prevalence of depression, anxiety, and self-esteem in collegiate student-athletes and differences between sex, academic status, (e.g., freshman, sophomore, etc.) and sport type (e.g., power, technical, etc.). Identify predictors for the risk of depression, anxiety, and low self-esteem. **Participants:** Collegiate student-athletes (n=615) completed a comprehensive mental health survey. **Methods:** Depression, anxiety, and self-esteem were assessed. Chi-square analyses examined differences across sex, academic status, and sport type. Multinomial logistic regression examined predictors for depression and anxiety risk. **Results:** Student-athletes (22.3%) were at risk for depression, anxiety (12.5%), and low self-esteem (8%). No significant differences were found for sex, academic status, and sport type for depression or self-esteem; however, there were significant differences for state and trait anxiety by sex. A significant association for depression and anxiety risk was found with females at risk. **Conclusions:** Signs and symptoms of depression and anxiety exist within the student-athlete population, despite a previous assumption of immunity.

Word Count: 151

Keywords: Student-athlete, mental health, prevalence, associations

Introduction

There are approximately half a million collegiate student-athletes in the National Collegiate Athletic Association (NCAA), attending over 1,000 colleges and universities in over 100 athletic conferences. According to the National Institute of Mental Health, approximately 7.1% of adults aged 18 or older experienced a depressive episode, and 19.1% had an anxiety disorder in the past year.[1,2] More specifically, within college-age

students ranging from 18-25, the prevalence was the highest for depression at 13.1% and 22.3% for anxiety disorders.[1,2] College is considered an at-risk period for the development of mental health illnesses. According to the American College Health Association, over 30% of students reported significant signs of depression.[2-4] College student-athletes are a subset of the young adult population and may be at risk for stressors linked to mental health issues (e.g., disordered eating, substance or alcohol abuse). With many student-athletes participating in sport, it is reasonable to believe numerous student-athletes are participate in their sport while managing signs and symptoms of depression and anxiety. With an increase in mental health visibility, an updated examination on the prevalence of depression, anxiety, and low self-esteem for this population is warranted.

Depression is characterized by mood changes, loss of interest or pleasure in daily activities and associated symptoms of sleep and eating problems, low energy, lack of concentration and self-worth.[2] With participation in sport, student-athletes are thought to be immune to mental health disorders like depression; however, research demonstrates the general college student population and student-athletes are comparable.[5,6] Research directly investigating prevalence and severity of depression symptoms in collegiate student-athletes varies by instruments used and by sports and sex examined. The prevalence of depressive symptoms in collegiate student-athletes ranges from 15.6% to 33.2%, with freshman and females typically reporting more symptoms.[5,7,8] When examining depression risk prevalence in specific sports including but not limited to football, baseball, wrestling, track and field, and lacrosse, the range was from 12.1% to 35.4% with higher rates consistent with females.[9-11] In current literature, sports have been categorized as individual and team sports when examining risk of depression in collegiate

student-athletes, indicating individual sports may be at an increased risk over team sports.[11,12] With a younger population, a lower prevalence rate of 8% was found for depression and anxiety, and specifically 13% for individual sports and 7% for team sports, further supporting sport type as a predictor for the risk of depression and anxiety in student-athletes.[12] The previous research on prevalence rates for team versus individual sports is based on a younger population and there are differences for measuring the presence of depression risk.

Anxiety is commonly known as a reaction to a perceived as stressful or dangerous situation that can have debilitating effects on daily activities and performance.[1] State anxiety refers to a temporary response to a stressful advent and trait anxiety is defined as a personality feature or predisposition.[13] Athletes often experience state anxiety during situations that create pressure, for example a free throw that determines the outcome of a basketball game. However, trait anxiety refers to a characteristic of a person, where an individual is anxious about general unknown outcomes. Researchers have identified high levels of trait anxiety may lead to an increase in state anxiety in performance.[14] However, there is limited research focusing on the examination of state and trait anxiety prevalence in student-athletes. According to the current literature by Li and colleagues,[15] one-third of student-athletes reported anxious symptoms prior to the season beginning with a significantly higher risk for sport injury. Furthermore, previous studies examining student-athletes, primarily occurred during preseason training and did not find significance for gender, sport, or academic status differences and the state and trait anxiety scores.[9,15] However, both studies by Yang et al.[9] and Li et al.,[15] indicated the link between depression and anxiety is associated with higher levels of pain and injury incidence. Therefore,

examining anxiety prevalence rates in student-athletes by sex, academic status, and sport type during in-season competition and determining additional risk factors for depression and anxiety is warranted to help clinicians prevent additional injury. Without further research on depression and anxiety prevalence, it is difficult to develop preventative mental health programs and interventions relevant to the current conditions.

Participation in sport facilitates positive mental health behaviors, including self-confidence, positive self-esteem, and social support.[16] Those who have positive mental health behaviors may be utilizing their social support systems to cope and manage stress in positive ways to lower risk for depression and anxiety. However, student-athletes may be more susceptible to mental health issues due to the demands of sport participation (e.g., sports injury, coach expectations, demands).[10] Student-athletes are thought to be protected from mental health issues because of increased self-esteem and a sense of connectedness and social support from their teammates.[16] There is an established relationship between self-esteem and depression, indicating self-esteem is a predictor for depression; however, updated research for student-athletes is needed.

Clinicians providing medical services within the collegiate sports setting should be mindful of comorbidities of mental illnesses present and which student-athletes are at the highest risk. Appropriate identification of high-risk individuals or sports may allow the clinician to intervene early before signs and symptoms begin to manifest. While all student-athletes have unique personal stressors and individual experiences, understanding the associations between depression, anxiety, self-esteem, sport type, and sex may help clinicians determine appropriate screening processes. Therefore, the purpose of this study was to examine the overall prevalence of depression, anxiety, and self-esteem in NCAA

Division I and II collegiate student-athletes; with a secondary purpose to examine differences between depression and anxiety risk, low self-esteem with demographic variables such as sex, academic status (e.g., freshman, sophomore, etc.), and sport type (e.g., power, ball sports, technical, endurance, etc.); and lastly to identify predictors of depression and anxiety risk and low self-esteem.

Methods

Participants

Participants were NCAA Division I and II student-athletes (n = 615; age 20 ± 1 years; males: n = 233, height = 184.1 ± 0.5 cm, weight = 91.5 ± 0.15 kg; females: n = 382, height = 168.4 ± 0.39 cm, weight = 63.25 kg) from across 40 institutions. To be included in the cross-sectional study, the student-athletes had to be between the ages of 18-26 and on an active roster during the time of the survey. The Institutional Review Board approved the study, and all participants consented prior to completing the survey.

Instruments

Demographic Information

The demographic information collected included: age, sex, self-reported height, weight, Body Mass Index (BMI), academic status, and sport. Academic status was defined as a freshman, sophomore, junior, or senior. Participants that were considered 5th-year seniors or graduate students were coded as a senior. Sport type was classified using prior classification by Sundgot-Borgen, by sorting sports into groups of endurance (i.e., cross country, track, swimming), aesthetic (i.e., cheerleading, diving, dance, equestrian), power (i.e., football), ball (i.e., baseball, softball, basketball, soccer, volleyball, beach volleyball), and technical sports (i.e., golf, tennis).[17]

Center for Epidemiologic Studies Depression Scale

The Center for Epidemiologic Studies Depression Scale (CESD) is a self-report measure of depressive symptoms. There are 8 different subscales, including: sadness, loss of interest, appetite, sleep, thinking/concentration, guilt, worthlessness, tired, fatigue, movement, suicidal ideation from the past week. Student-athletes selected how often they have felt or behaved on a scale of 1 = rarely or none of the time to 4 = most or all the time during the past week. Any scores higher than 16 indicates an individual is at risk for depression.[18,19] The internal consistency for the CESD is r = 0.85 to 0.90, with a test-retest reliability of r = 0.45- 0.7, and r = .91 for this study.[19,20]

State Trait Anxiety Inventory

The State Trait Anxiety Inventory (STAI) is a self-report tool that indicates anxiety and distinguishes between state (a temporary condition in specific situations) and trait (general tendency to perceive situations as threatening) anxiety. The first 20 questions consist of statements examining how individuals feel "right now at this moment," and individuals respond on a scale of 1 = Not at all to 4 = Very much so. The second 20 questions examine how individuals "generally feel" on a scale of 1 = almost never to 4 = almost always.[13,21] For the STAI, the internal consistency coefficients range from r = 0.86 to 0.95 and the test-retest reliability range from r = 0.65 to .75.[13] The reliability for the STAI in this study r = 0.95.

Rosenberg Self-Esteem Scale

The Rosenberg Self-Esteem Scale (RSES) is one of the most widely used measures of self-esteem.[22,23] The scale consists of 10 items that are rated on a 4-point Likert scale assessing how an individual thinks and feels about themselves (e.g., strongly agree = 3,

agree = 2, disagree = 1, and strongly disagree = 0). Each participant's responses are summed across the 10 items and further categorized as low self-esteem or at risk (below 15) or not at risk or high self-esteem (above 15).[22] The scale has been validated for college populations with a test-retest reliability ranging from 0.85 to 0.88[22] with excellent stability and 0.90 for this study.[23]

Procedures

Upon receiving approval from the University of South Carolina Institution Review Board, participants were recruited using a snowball sampling method. Athletic trainers who worked directly with student-athletes at NCAA Division I or II intuitions were contacted with an invitation letter and a survey link and asked to forward the invitation to their student-athletes. The web-based online survey (SurveyMonkey, San Mateo, CA) included an invitation/consent letter, the demographic items followed by the CESD, STAI, and the RSES. The survey was available for 30 days with a follow-up reminder sent to the participant every 10 days until the window closed.

Statistical Analysis

We used SPSS statistical software (Version 27; SPSS Inc. Armonk, NY) with an alpha set at $p < .05$ for all analyses. We used G*Power 3 (version 3.1.9.2., Heinrich Heine University, Dusseldorf, Germany) software to calculate power.[24] Using an alpha of .05 and a small effect size, our power calculation indicated we needed a sample of 271 completed surveys to achieve an estimated power of 0.95.[24,25] We performed basic descriptive statistics to examine the demographic information (e.g., height, weight, age, body mass index (BMI), sex, academic status, etc.). Chi-Squared analyses were used to determine differences between depression, anxiety, and self-esteem risk, sex, academic status, and

sport type. The results of the chi-squared tests were used to select predictor variables to assess for each outcome using multinomial logistic regression. Education, sport, and ethnicity were not analyzed due to results from the chi-squared analyses, and sex was examined as a predictor for the outcome variables.

Results

A total of 821 student-athletes initiated the survey, 675 had partially completed the survey, and 615 student-athletes had fully completed the survey (75% completion rate). Student-athletes included in this study were from 40 institution across 22 different teams which were categorized into endurance sports (n = 171), aesthetic sports (n = 102), power sports, (n = 117), ball sports (n = 194), and technical sports (n = 31). Detailed demographic information can be found in Table 2.1.

Prevalence of Depression Risk

Overall, 22.3% (n = 137/615) of student-athletes were classified as at risk for depression. Chi-squared analysis revealed no significant differences between the CES-D and sex [$X^2(1, n = 615) = .00, p = .99$], with females (22.3%) reporting the same risk as males (22.3%). Refer to Table 2.2 for sex distribution. No significant differences were identified for depression risk and academic status [$X^2(3, n = 615) = 6.36, p = .095$, Table 3], with sophomores (n = 45/154, 29.2%) and juniors (n = 33/149, 22.1%) reporting the highest depression risk. Chi-squared analysis revealed no significant differences between the CES-D and sport type [$X^2(4, n = 615) = 3.427, p = .489$], with ball ($n$ = 48/194, 24.7%) and power (n = 28/117, 23.9%) sports reporting the highest risk. The distribution for CES-D risk and sport type can be found in Table 2.3.

Prevalence of Anxiety Risk

Overall, 8.5% (n = 52/615) of student-athletes were classified as over the norm means for college aged students for state anxiety, and 12.5% (n = 77/615) for trait anxiety. For state anxiety and trait anxiety, 66.7% (n = 410/615) and 57.4% (n = 353/615) respectively fell within the college student norms. The overall raw mean scores and standard deviations by sex are found in Table 2.4. Chi-squared analysis revealed a significant difference for state anxiety and sex [$X^2(2, n = 615) = 10.46$, $p = .005$] and for trait anxiety and sex [$X^2(2, n = 615) = 10.32$, $p = .006$]. Refer to Table 2.2 for the distribution of state and trait anxiety by sex. There were no differences found for state and trait anxiety for academic status [$X^2(6, n = 615) = 5.23$, $p = .515$], [$X^2(6, n = 615) = 4.42$, $p = .620$] or for sport type [$X^2(8, n = 615) = 12.25$, $p = .141$], [$X^2(8, n = 615) = 4.27$, $p = .832$].

Prevalence of Low-Self Esteem

Overall, 8.0% (n = 49/615) of student-athletes were classified as being at risk for low self-esteem. Chi-squared analysis revealed no significant differences between the RSES and sex [$X^2(1, n = 615) = 1.112$, $p = .292$], with females (7.1%) reporting a lower risk than males (9.4%). Refer to Table 2.2 for the sex distribution for RSES. No significant differences were identified for low self-esteem and academic status [$X^2(3, n = 615) = .394$, $p = .942$, Table 3], with sophomores (n = 14/154, 9.1%) and juniors (n = 10/125, 8.0%) reporting scores indicating low self-esteem. Chi-squared analysis revealed no significant differences between the RSES and sport type [$X^2(4, n = 615) = 4.094$, $p = .393$], with power (n = 12/117, 10.3%) and endurance (n =17/171, 9.9%) sports reporting low self-esteem. The distribution for the RSES and sport type can be found in Table 2.3.

Multinomial logistic regression

Results of the multinomial analysis indicated that sex is associated with depression risk, and state and trait anxiety risk. For depression risk, females are more likely to be at risk for depression when compared to males with an odds ratio of 1.795 (CI: 1.184, 2.722). Females are more likely to be within the average college student mean for state anxiety as compared to males with an odds ratio of 1.771 (CI: 1.214, 2.585) with an increase in odds by 77.1%. As for trait anxiety, females are more likely to be within or above the average college student mean for trait anxiety as compared to males with an odds ratio of 1.427 (CI: .994, 2.048) and 2.539 (CI: 1.402, 4.596), respectively.

Discussion

This study examines the prevalence rates for depression risk, anxiety risk and low self-esteem risk in a large NCAA Division I and II collegiate student-athlete sample. In addition, this study expands on earlier research by examining sport type classifications investigates sex, academic status, and sport type as a predictor of depression risk or anxiety risk. Furthermore, this study compares findings with previous sport categorizations and provides suggestions for future intervention.

Depression

Despite increased recognition of the importance of mental health in student-athletes, prevalence rates are still high when comparing with previous literature. We found an overall prevalence of 22.3% for depression risk, similar to previous research in student-athletes using the CES-D.[8,9,15] With the risk for depression at 22.3%, nearly 1 in every 4 student-athletes report signs and symptoms of depression. Collegiate student-athletes not only have an expectation of being successful athletically, but they are also required to

succeed personally and academically. Student-athletes are required to maintain a balance between academics and their specific sport requirements, placing undue stress on the student-athletes increasing their risk for depression. While there were no significant differences for sex, this study demonstrated more females reported signs and symptoms of depression with the CES-D. Our findings support the suggestion that females may be at a higher risk for depression than males, further supporting previous efforts examining depression prevalence in student-athletes.[7-10,26] When considering the distribution of sex in the sport classification, power and ball sport groups had the highest percentage for reported symptoms. Although sport type was not found to be significant, each sport type has its own associated risk factors. Sports have been previously classified by team and individual sports, rather than by the sport types proposed by Sundgot-Borgen.[17] When examining sex as a predictor for depression, significant associations were found, indicating females are more likely to report depressive symptoms than males, consistent with prior research.[9]

In addition, no significant differences were found for academic status, indicating the risk of depression was consistent across education levels. Contrary to previous research, freshmen or underclassmen have been identified to be more at risk when compared to the other education levels.[7,9] Our results have also indicated academic status was not a significant predictor for depression risk. While the results are insignificant, it is essential to note mental health interventions may be beneficial for all academic levels. Each academic class is entitled to individual stressors. For example, freshmen learn to adapt to a new home, friends, classes, and living situation while adjusting to the new team, coach, and expectations. Whereas, seniors are preparing to finish their athletic careers, graduate, and become working professionals in their field of study. Mental health interventions

geared to instruct student-athletes on coping mechanisms, time management skills, and self-care may help reduce the mental health prevalence among all student-athletes regardless of academic status.

It has been previously suggested individual sports are at a higher risk for depression than team sports, and furthermore indicating sport type is a predictor for depression risks.[11,12] When examining sport in our study, we categorized our sports by the recommendations of Sundgot-Borgen.[17] With this categorization, we have found no differences for sport type and depression risk; however, it is important to note, ball (e.g., basketball, soccer) and power sports (e.g., football) were the highest among sport types. Ball and power sports would fall into the category of a team sport and while insignificant, both sport groups were higher than others that would be categorized as individual sports. The ball sport category included both females and males, while power included only football athletes. Sport type was also not found to be a significant predictor of depression risk. Prior research has indicated that individual sports are significantly more likely to report signs and symptoms of depression than team sports,[11] and our findings of ball and power sports at a higher risk than the other sport types contradicts this finding.

Anxiety

In collegiate student-athletes, there is limited research on the prevalence of state and trait anxiety.[9,15] Prior research has examined state and trait anxiety in student-athletes during their preseason and found no differences for sex[9,15] or collegiate class.[9] Our results are consistent with those of Yang and colleagues[9] and demonstrate that the student-athletes' state and trait scores are significantly lower than that of typical college students.[21] While student-athletes are reporting scores lower than regular college students; our results

demonstrate that student-athletes are still demonstrating signs and symptoms of anxiety. In addition, when examining sex as a predictor for anxiety, females are more likely to be at or above the average mean for both state and trait anxiety. It has been suggested with an increase in trait anxiety, state anxiety scores may increase and affect performance.[14]

In addition, no significant differences were found for state or trait anxiety scores across academic status, which is supported by Yang and colleagues,[9] who revealed similar findings for anxiety scores. While insignificant, it was suggested female, freshman, or juniors had a higher tendency to report symptoms than their counterparts.[9] With increased stress to maintain academic standards, it is interesting the scores for trait anxiety were not higher. Student-athletes are required to maintain a specific grade point average each semester to maintain their scholarship and ability to participate. A general fear or worry of maintaining these requirements does not seem to be higher than that of a typical college student. Furthermore, academic status was not a significant predictor for anxiety scores in our study. Although insignificant, student-athletes are still reporting anxiety. Support programs and more options for tutoring and academic success may be beneficial for all student-athletes to be successful both in the classroom and in their athletic performances.

Similar to academic status, no significant differences were found for sport type and anxiety risks. When considering state anxiety and sport, athletes would typically experience symptoms of anxiety directly after or during stressful situations.[27,28] The participants in our study were able to complete the survey at their convenience; therefore, it is possible the student-athletes were not completing the survey in a "non-stressful" environment and were truly not experiencing state anxiety. In the context of sport competition, state anxiety scores are known to increase during or directly after situations

that are perceived as stressful. Therefore, future research in student-athletes may benefit from an examination of anxiety states throughout a competitive season.

Low Self-Esteem

Low self-esteem is not a mental health disorder, rather a behavior that can be a risk factor for depression and anxiety.[16,29] Individuals experiencing low self-esteem may have an inadequate perception of their performance possibly predisposing them to mental health problems. Our study indicated only 8% of student-athletes reported low self-esteem. Whereas prior research has been consistent, indicating student-athletes have a higher sense of self-esteem when compared to non-athletes.[16] Furthermore, in a study examining college nursing students, over 70% reported low self-esteem and high academic stress.[30] From the results of our study, student-athletes have a higher sense of self-esteem when compared to non-athletes and college nursing students. In our study, no differences were found for academic status nor sport type. While previous studies did not specifically break down sport-types and examine self-esteem, student-athletes participating in "lean" sports tend to have lower self-esteem that becomes a predictor for other mental health disorders such as eating disorders.[31] However, in our study, power and endurance athletes reported higher scores indicating a lower self-esteem when compared to the other sport types. Endurance athletes would fall into the category of lean sports; however, power sports would not. These results demonstrate that low self-esteem occurs in both females and males, though at a low rate. Although self-esteem does not seem to be a high-risk factor for student-athletes, the prevalence rates for depression and anxiety have stayed consistent with previous research indicating change is not occurring.

Limitations

The current study's findings emphasize the importance of investigating prevalence of depression and anxiety risks in collegiate student-athletes. The study, however, is not without its limitations. First, it is important to note that the data is self-reported by the athletes and depends on the participants' honest answers. The self-report tools are not used to determine a diagnosis, instead indicate whether an individual is at risk. Additionally, when the data were categorized by sport, it is important to recognize that there were no females in the power sport category. Based on the findings, we suggest that future research explore more possible risk factors (e.g., scholarship status, previous history of mental health, season type) and predictors of depression and anxiety in student-athletes to create mental health interventions.

We also were unable to examine the data by NCAA Division level due to the design of the survey; however; an examination by division level may provide additional insight into risk differences. Lastly, current mental health interventions are loosely focused on improving mental health awareness and decreasing stigma, and future research should focus on creating mental health interventions designed to reduce signs and symptoms of depression and anxiety. Heart rate biofeedback has been shown to improve performance for student-athletes,[32] and research in collegiate students has determined it could be effective for reducing signs and symptoms of depression and anxiety.[33-35] Prior Heart Rate Variability (HRV) research in endurance athletes, with athletic conditioning, has demonstrated an increased vagal tone indicating improved performance and regulation of emotional and mental health. Therefore, it is possible in the sport groups of ball and power, HRV training may improve their regulation of emotional and mental health. [36,37]

Conclusions

The present study sought to establish the prevalence of depression risk, anxiety risk, low self-esteem risk, and determine if sex, academic status, or sport type were predictors. It suggests depression and anxiety signs and symptoms are present in the student-athlete population, with females predominantly more at risk than males. No differences were found for academic status or sport type, and neither were determined to be risk factors for our study. Self-esteem does not seem to have a significant role in mental health for student-athletes; however, other risk factors need to be examined for implications on depression and anxiety risk.

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Declaration of Interest Statement

The authors have no conflicts of interest to report. The authors confirm the data presented in this study met ethical guidelines and received approval from the Institutional Review Board of the University of South Carolina.

References

1. Anxiety Disorder. National Institute of Mental Health. https://www.nimh.nih.gov/health/statistics/any-anxiety-disorder.shtml. Published 2017. Updated November 2017. Accessed February 19, 2019.
2. National Alliance on Mental Illness; Depression. Published 2015. Updated March 2015. Accessed January 30, 2019.

3. American College Health Association National College Health Assessment. American College Health Association. Accessed February 24, 2019.
4. Kessler RC, Wang PS. The descriptive epidemiology of commonly occurring mental disorders in the United States. *Annu Rev Public Health.* 2008;29:115-129.
5. Proctor SL, Boan-Lenzo C. Prevalence of depressive symptoms in male intercollegiate student-athletes and nonathletes. *J Clin Sport Psychol.* 2010;4(3):204-220.
6. Ibrahim AK, Kelly SJ, Adams CE, Glazebrook C. A systematic review of studies of depression prevalence in university students. *Psychiatry Res.* 2013;47(3):391-400.
7. Cox CE, Ross-Stewart L, Foltz BD. Investigating the prevalence and risk factors of depression symptoms among NCAA division I collegiate athletes. *J Sports Sci.* 2017;5:14-28.
8. Wolanin A, Hong E, Marks D, Panchoo K, Gross M. Prevalence of clinically elevated depressive symptoms in college athletes and differences by gender and sport. *Br J Sports Med.* 2016;50(3):167-171.
9. Yang J, Peek-Asa C, Corlette J, Cheng G, Foster D, Albright J. Prevalence of and risk factors associated with symptoms of depression in competitive collegiate student athletes. *Clin J Sport Med.* 2007;17(6):481-487.
10. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.
11. Martignetti A, Arthur-Cameselle J, Keeler L, Chalmers G. The relationship between burnout and depression in intercollegiate athletes: An examination of

gender and sport-type. *Journal for the Study of Sports and Athletes in Education.* 2020;14(2):100-122.

12. Pluhar E, McCracken C, Griffith KL, Christino MA, Sugimoto D, Meehan WP, 3rd. Team sport athletes may be less likely to suffer anxiety or depression than individual sport athletes. *J Sci Med Sport.* 2019;18(3):490-496.

13. Spielberger C. *State-Trait Anxiey Inventory: Bibliography.* 2nd ed. Palo Alto, CA: Consulting Psychologists Press; 1989.

14. Horikawa M, Yagi A. The relationships among trait anxiety, state anxiety and the goal performance of penalty shoot-out by university soccer players. *PLoS One.* 2012;7(4):e35727.

15. Li H, Moreland JJ, Peek-Asa C, Yang J. Preseason anxiety and depressive symptoms and prospective injury risk in collegiate athletes. *Am J Sports Med.* 2017;45(9):2148-2155.

16. Armstrong S, Oomen-Early J. Social connectedness, self-esteem, and depression symptomatology among collegiate athletes versus nonathletes. *J Am Coll Health.* 2009;57(5):521-526.

17. Sundgot-Borgen J. Nutrient intake of female elite athletes suffering from eating disorders. *Int J Sport Nutr.* 1993;3(4):431-442.

18. Radloff LS. The CES-D scale: A self-report depression scale for research in the general population. *Applied psychological measurement.* 1977;1(3):385-401.

19. Radloff LS. The use of the center for epidemiologic studies depression scale in adolescents and young adults. *J Youth Adolesc.* 1991;20(2):149-166.

20. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1(3):385-401.

21. Spielberger C, Gorsuch R, Lushene P, Vagg P, Jacobs A. Manual for the State-Trait Anxiety Inventory (Form Y)(Consulting Psychologists, Palo Alto, CA). 1983.

22. Rosenberg M. Society and the adolescent self-concept. In: Princeton, NJ: Princeton University Press; 1965.

23. Rosenberg M. Rosenberg self-esteem scale (RSE). *Acceptance and commitment therapy Measures package.* 1965;61(52):18.

24. Faul F, Erdfelder E, Lang A-G, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods.* 2007;39(2):175-191.

25. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods.* 2009;41(4):1149-1160.

26. Reardon CL, Hainline B, Aron CM, et al. Mental health in elite athletes: international olympic committee consensus statement (2019). *Br J Sports Med.* 2019;53(11):667-699.

27. Hale B, Koch K, Raglin J. State anxiety responses to 60 minutes of cross training. *Br J Sports Med.* 2002;36(2):105-107.

28. Ford JL, Ildefonso K, Jones ML, Arvinen-Barrow M. Sport-related anxiety: current insights. *Open access journal of sports medicine.* 2017;8:205-212.

29. Koivula N, Hassmén P, Fallby J. Self-esteem and perfectionism in elite athletes: effects on competitive anxiety and self-confidence. *Personality and individual differences.* 2002;32(5):865-875.

30. Acharya Pandey R, Chalise HN. Self-esteem and academic stress among nursing students. *Kathmandu Univ Med J (KUMJ).* 2015;13(52):298-302.

31. Engel SG, Johnson C, Powers PS, et al. Predictors of disordered eating in a sample of elite division I college athletes. *Eat Behav.* 2003;4(4):333-343.

32. Jimenez Morgan S, Molina Mora JA. Effect of Heart Rate Variability Biofeedback on Sport Performance, a Systematic Review. *Appl Psychophysiol Biofeedback.* 2017;42(3):235-245.

33. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Archives of general psychiatry.* 1961;4(6):561-571.

34. Ratanasiripong P, Ratanasiripong N, Kathalae D. Biofeedback Intervention for Stress and Anxiety among Nursing Students: A Randomized Controlled Trial. *ISRN Nurs.* 2012;2012:827972.

35. Ratanasiripong P, Sverduk K, Prince J, Hayashino D. Biofeedback and counseling for stress and anxiety among college students. *Journal of College Student Development.* 2012;53(5):742-749.

36. Laborde S, Mosley E, Thayer JF. Heart rate variability and cardiac vagal tone in psychophysiological research - recommendations for experiment planning, data analysis, and data reporting. *Front Psychol.* 2017;8:213-213.

37. Dong J-G. The role of heart rate variability in sports physiology. *Exp Ther Med.* 2016;11(5):1531-1536.

Table 2.1. Demographic information including academic status, sport type and ethnicity (n = 615).

	All (n = 615)		Females (n = 382)		Males (n = 233)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	19.6	1.3	19.5	0.1	19.7	0.1
Height (cm)	174.3	10.8	168.4	0.4	184.1	0.5
Weight (kg)	80.0	19.8	63.3	0.5	92.5	1.3
BMI (kg/cm^2)	24.0	4.3	22.3	0.2	26.9	0.3
Academic Status	*%*	*n*	*%*	*n*	*%*	*n*
Freshman	30.4	187	17.1	105	13.3	82
Sophomore	25.0	154	16.1	99	8.9	55
Junior	24.2	149	14.8	91	9.4	58
Senior	20.3	125	14.1	87	6.2	38
Sport Type	*%*	*n*	*%*	*n*	*%*	*n*
Endurance	27.8	171	20.5	126	7.3	45
Aesthetic	16.6	102	16.1	99	0.5	3
Power	19.0	117	0	0	19.0	117
Ball	31.5	194	22.0	135	9.6	59
Technical	5.0	31	3.6	22	1.5	9
Ethnicity	*%*	*n*	*%*	*n*	*%*	*n*
African American	20.5	126	5.5	34	15.0	92
Asian American	1.1	7	0.7	4	0.5	3
Hispanic American	1.8	11	1.0	6	0.8	5
Caucasian	72.2	444	51.7	318	20.5	126
Indian/Native American	0.7	4	0.5	3	0.2	1
"Other"	3.7	23	2.8	17	1.0	6

Table 2.2 Prevalence of collegiate student-athletes (*n*=615) classified as "At risk" for Depressive Symptoms and Low Self-Esteem, and above norms for Anxiety is presented by sex. Values are presented in percent (%) and frequency (n)

Sex	**Depressive Symptoms (%)**	**Frequency (*n*)**	X^2	***p* = value**
Overall	22.3	137	0.00	.99
Females	22.3	85		
Males	22.3	52		
	Low Self-Esteem (%)	**Frequency (*n*)**	X^2	***p* = value**
Overall	8.0	49	1.11	.29
Females	7.1	27		
Males	9.4	22		
	State Anxiety (%)	**Frequency (*n*)**	X^2	***p* = value**
Overall	8.5	52	10.46	.005*
Females	7.3	28		
Males	10.3	24		
	Trait Anxiety (%)	**Frequency (*n*)**	X^2	***p* = value**
Overall	12.5	77	10.32	.006*
Females	15.2	58		
Males	8.2	19		

*P Values ≤.05

**State and Trait Anxiety were measured using the State-Trait Anxiety Inventory. The college student norms were used for analyses. State Anxiety means and standard deviation for Females 38.76 (11.96) and Males 46.47 (10.02), and Trait Anxiety for Females 40.40 (10.15) and Males 38.30 (9.18).

Table 2.3 Prevalence of collegiate student-athletes (n = 615) classified as "At risk" for Depressive Symptoms and Low Self Esteem is presented by academic status and sport type. Values are presented in percent (%) and frequency (n).

Academic Status	**Depressive Symptoms (%)**	**Frequency (*n*)**	X^2	***p* = value**
Overall	22.3	137	6.36	.10
Freshman	19.3	36		
Sophomore	29.2	45		
Junior	22.1	33		
Senior	18.4	23		
Academic Status	**Low Self-Esteem (%)**	**Frequency (*n*)**	X^2	***p* = value**
Overall	8.0	49	0.39	.94
Freshman	7.5	14		
Sophomore	9.1	14		
Junior	7.4	11		
Senior	8.0	10		
Sport Type	**Depressive Symptoms (%)**	**Frequency (*n*)**	X^2	***p* = value**
Overall	22.3	137	3.43	.49
Endurance	22.2	38		
Aesthetic	15.7	16		
Power	23.9	28		
Ball	24.7	48		
Technical	22.6	7		
Sport Type	**Low Self-Esteem (%)**	**Frequency (*n*)**	X^2	***p* = value**
Overall	8.0	49	4.10	.39
Endurance	9.9	17		
Aesthetic	7.8	8		
Power	10.3	12		
Ball	5.7	11		
Technical	3.2	1		

Table 2.4 Raw State and Trait Anxiety Scores. Values are presented in Mean (SD).

Sex	State Anxiety	Trait Anxiety
Overall	34.25 (10.13)	25.78 (9.42)
Females	35.34 (10.13)	36.73 (9.50)
Males	32.49 (9.88)	34.15 (9.05)

**State and Trait Anxiety were measured using the State-Trait Anxiety Inventory. The college student norms were used for analyses. State Anxiety means and standard deviation for Females 38.76 (11.96) and Males 46.47 (10.02), and Trait Anxiety for Females 40.40 (10.15) and Males 38.30 (9.18).

Chapter 3

Effects of a 4-Week Heart Rate Variability Biofeedback Intervention on Psychological and Performance Variables in Student-Athletes: A Pilot Study[1]

[1]Samantha R. Weber; Toni M. Torres-McGehee; Zachary Winkelmann; Eva Monsma; Shawn Arent. To be submitted to Athletic Training and Sports Health Care (in preparation).

Abstract

Purpose: To examine the effects and experiences of a 4-week biofeedback intervention on coherence, psychological, and performance variables in collegiate student-athletes. **Methods:** Thirteen student-athletes were randomly assigned to the intervention (one weekly biofeedback session for 4-weeks) or control group (no sessions). Data were collected at pre and post-intervention using weekly averaged coherence scores, psychological measures for depression, arousal, stress, resiliency, and performance outcome measures. Post-intervention participants from the intervention group completed a survey on their experiences. **Results:** No significant differences were found for "at rest", pre or post-practice coherence scores, for the 4 psychological instruments, or for perceived recovery. Significant differences were found for performance by time ($p = .029$) but not for group ($p = .306$). Three major themes emerged from the surveys including, breathing techniques, experience, and effects. Subthemes for experience included positive, visual appeal, novice, negative and for effects included tranquility, improvements in focus and neutrality. **Conclusions:** Biofeedback did not improve coherence, psychological, or performance variables; however, student-athletes reported self-perceived positive benefits and effects from the intervention.

Word Count: 170 words

Introduction

Participation in college athletics has been documented to change the behavioral response of the individual through additional stress, increased episodes of anger, and symptoms of depression and anxiety due to sport performance.[1] Although sport has many positive effects, the mental health struggles of college student-athletes was recognized by

the National Collegiate Athletic Association (NCAA) Sport Science Institute with a mission to improve access to quality mental healthcare and normalize mental health care seeking behavior. The NCAA encourages prevention and wellness programs at all institutions and provides resources to help institutions implement best practice guidelines.[2] While the NCAA initiatives are promising, current prevention and intervention programs for student-athletes are psychoeducational and limited in nature. The available programs are not designed to reduce symptoms of depression, anxiety or stress, rather they are loosely designed to inform mental health awareness and encourage student-athletes to seek help.[3,4] The gap in the programming provides ample opportunity to implement interventions designed to improve mental health symptoms in current, competing student-athletes.

In addition to maintaining mental health and wellness, collegiate student-athletes need to incorporate appropriate recovery mechanisms for optimal performance.[5] Recovery is defined as a multifaceted restorative process relative to time, which can be disrupted by internal or external factors such as stress or fatigue.[6] The internal and external factors dually affect student-athletes through a need for both physiological and psychological maintenance in their daily life and sport. Adequate recovery can be achieved through the use of numerous interventions including sleep hygiene,[7] cognitive self-regulation,[8] and psychological relaxation techniques[5] that can be paired with biofeedback modalities such as heart rate variability (HRV).

Heart rate variability consists of changes and fluctuations in the time intervals between consecutive heartbeats.[9] The interaction of regulatory systems contribute to HRV recordings and more specifically, the autonomic, cardiovascular, and respiratory systems

produce short-term HRV measurements.[10] The importance of HRV is demonstrated when the cardiovascular system effectively modulates vagal tone via the vagus nerve. For example, when an individual inhales, heart rate increases due to a withdrawal of vagus nerve inhibition and during exhalation, vagal inhibition is restored and thus slows the heart down. This process is largely responsible for generating HRV and helps maintain the dynamic autonomic balance within the body.[10] HRV is detected through Electrocardiogram (ECG) or through photoplethysmography (PPG) sensors that detect the interbeat interval. ECG is more accurate than PPG and is used as the gold standard for measuring HRV. [9-11] The ECG measures each QRS complex and normal to normal intervals and reflects cardiac activity.[9-11] The PPG method is most commonly used in wearable devices on the wrist or ear. This non-invasive technique uses a light technology and photodetector at the skin's surface to measure variations in the circulation of blood.[12] HRV has been used for parameters when designing training and recovery programs for athletes. In a comparison of sedentary subjects and recreationally active subjects, a distinct HRV profile was noted for active individuals including an overall increase in HRV and parasympathetic cardiac modulation.[13] Furthermore, in those with higher vagal tone, athletic conditioning is an important factor influencing autonomic control of the heart to influence performance and the regulation of emotional and mental health.[13,14]

Heart rate variability through biofeedback has primarily been used to improve concentration and performance.[8,15] Through biofeedback, individuals can learn to recognize their heart rate patterns as erratic and ineffective and in turn regulate their breathing to control the heart rate pattern. Previous studies have indicated that through HRV biofeedback interventions, student-athletes were able to lower anxiety, lower their

heart rate, and improve their heart rate coherence.[8,16-18] One example of HRV biofeedback technology has been established through the HeartMath Institute (Heart Math Institute, Boulder CA). HeartMath has created self-regulation breathing techniques and numerous methods of obtaining heart rate biofeedback data including their systems EmWave and Inner Balance. EmWave has been used to help student-athletes achieve their optimal training zone and improve overall performance; however, the EmWave system is a computer-based software, that does not allow for hands free, quick, and on the go biofeedback results.[8,17] The other method, Inner Balance, can be easily accessed through a smart phone mobile application and the heart rate monitor connects via Bluetooth technology. To date there is limited research on student-athletes and their use of the HeartMath self-regulation techniques, technology, and more specifically with the Inner Balance method. Utilization of hands-free Bluetooth technology, would allow student-athletes the opportunity to regulate their breathing and manage their stress and emotions when it is convenient for their schedules and without a computer. To our knowledge, Inner Balance has not been used in student-athletes to improve mental health status and performance outcomes.

The literature on biofeedback programs designed for mental health outcomes in combination with performance outcomes in student-athletes is limited and cross sectional in nature. [8,15,17] Therefore, the objective of our pilot study was to examine the effects of a 4-week heart rate biofeedback intervention on coherence, psychological (i.e., depressive symptoms, level of activation, perceived stress, resilience), and performance variables in collegiate student-athletes. A secondary aim to describe the experience of individuals who used the heart rate biofeedback intervention to determine if there were any lasting effects.

We believe the outcomes of the study may be valuable to athletic trainers, coaches, and strength and conditioning professionals when providing mental wellness and performance enhancement strategies to student-athletes.

Methods

Participants

Thirteen female student-athletes (age: 20 ± 1 years, height: 166.3 ± 8.7 cm, weight: 73.3 ± 19.0 kg) were recruited from local colleges and universities to participate in the study. All student-athletes were currently participating in their respective sport and free of injury at the onset of the study. If a participant was injured during the study period, they were able to continue in the study. This study was approved by the University of South Carolina Institutional Review Board, and participants consented prior to participation.

Instruments

Demographics

The initial screening questionnaire including items relative to personal information (e.g., age, sex, injury status, sport, season of sport, etc.) to determine eligibility for the study and collect demographic factors including self-reported anthropometric measurements (e.g., height, weight).

Coherence

Coherence is the term to measure communication between the heart and brain and refers to the interactions between physiological and psychological processes for optimal functioning.[19] In HRV, distinct heart rate patterns characterize different emotional states. In individuals with high coherence, a smooth, sine wave like pattern is seen on the Inner Balance display screen and on the contrary, low coherence will have an erratic heart rate

pattern. The Inner Balance mobile application uses a patented algorithm to determine heart coherence and HRV.[19] The coherence score was obtained from the earpiece heart rate sensor, graphed and recorded in real time on the Inner Balance application. Higher coherence scores reflected psychophysiological control and balance.[19] The Inner Balance application provided a low, medium, or high coherence score reflecting the individual's ability to balance the autonomic system ranging from 0-16. Scores of 0.5 are considered to be beginner level, 1.0 as good, 2.0 very good, and 3.0 and up is excellent. The coherence score was recorded daily with an "at rest" measure (no skill practice) and then measures pre- and post-team practice sessions. Daily coherence scores were averaged at the end of each week.

Psychological Variables

For the purposes of the study, the research team used 4 valid and reliable measures to assess psychological components of the participants, regardless of group allocation, during the study. The 4 measures were for depression, arousal, stress, and resiliency.

First, we used the Center for Epidemiologic Studies Depression Scale (CESD) as a self-report measure of depressive symptoms. The CESD is a 20 item tool that measured 8 different components including: depressed mood, feelings of guilt and worthlessness, psychomotor retardation, loss of appetite and sleep disturbance.[20] Participants selected how often during the past week they have felt or behaved respective to certain items using a 4-point Likert scale (*1= rarely or none of the time to 4 = most or all of the time*). If a participant would be considered at risk for depression if they scored >16 on the CESD. The internal consistency for the CESD α = 0.85 to 0.90, with a test-retest reliability of α = 0.45-0.70.[20]

Next, we assessed arousal using the multi-dimensional Activation-Deactivation Adjective Check List (AD-ACL). The AD-ACL consists of 20 adjectives related to energy (general activation), tiredness (deactivation-sleep), tension (high activation), and calmness (general deactivation) which are the four subscales of the arousal states of energetic and tense arousal.[21] The AD-ACL instructs the individual to use the rating scale to describe their feelings at that moment, and to use their first reaction. The rating scale has four options to circle/mark. A selection of (vv) or double check means the individual definitely feels that mood or feeling at the moment, whereas a selection of (v) or single check means the individual slightly feels that mood or feeling at the moment. A selection of (?) or question mark means the word does not apply or the individual cannot decide if they feel that mood or feeling now. If the individual selects no, that individual is not feeling that mood or feeling now. The AD-ACL is scored by summing the ten scores for the energy and tension dimensions. These two dimensions are the best indications of energetic and tense arousal, and a full use of all dimensions reduces the relationship strength between arousal and other behaviors. The test-retest reliability for the four subscales ranges from 0.79 – 0.93, and for the two specific subscales of energy 0.89 and tension 0.93.[21,22]

We measured stress using the College Student Stress Scale (CSSS) a screening instrument for students experiencing stress during the transition to college. The purpose of the instrument is to identify those who believe the transition is highly stressful.[23] The CSSS includes 11 items that are answered with a 5-point Likert scale to assess how frequently they are distressed, anxious, or question their ability. The CSSS has good internal consistency and stability with an alpha for the total score of 0.87.[23]

Finally, we measured resiliency using the reliable Brief Resilience Scale (BRS). The instrument is used to assess the ability of an individual to bounce back from adversity using 6 statements measured on a 5-point Likert scale (1= strongly disagree to 5= strongly agree).[24] To score the BRS, add the responses on the 6 statements, with reverse scoring for items 2, 4, and 6. After summing the scores, divide the total by the total number of questions answered. Scores ranging from 1.00 to 2.99 indicate low resilience, 3.00-4.30 normal resilience, and 4.31 to 5.00 high resilience.[24]

Performance & Recovery

To assess performance and recovery, the participants completed 3 instruments including the Perceived Recovery Status Scale (PRSS), the Sport Performance Rating Scale (SPR), and the Athlete Sleep Screening Questionnaire (ASSQ). The PRSS was created to assess an individual's perceived recovery status on a scale of 0-10 similar in nature to the Rated Perceived Exertion Scale. [25] The scale ranges from 0 (very poorly recovered) to 10 (very well recovered). A decline in performance would be expected with scores from 0 to 3. With scores between a 4 and 7 a similar level of performance would be expected. With any scores of 8 to 10 an improved performance would be expected.[25]

Next, the SPR was used for participants to rate their perceived performance on a scale of 0 (worst performance) to 10 (best performance) for after each practice session. Prior studies used sport specific rubrics to assess performance, therefore, the SPR was created to allow for multiple teams to assess their performance. This numeric rating scale has been deemed reliable and used for pain studies and further rating the intensity of pain.[26]

Finally, the ASSQ was used to detect sleep disturbances and daytime dysfunction in the student-athlete population. The ASSQ consists of 15 items that assess sleep quality,

insomnia and chronotype with a timeframe of "over the recent past."[27] The sleep difficulty score from the ASSQ is used to classify the student-athletes into a level of sleep problems (none, mild, moderate, severe) based on their responses. The cut off scores for each classification include none: 0-4, mild: 5-7, moderate: 8-10, and severe: 11-17.[27] The ASSQ includes modifiers that are not included in the SDS score but can be used to create sleep recommendations. The ASSQ has an internal consistency of 0.74 and test-retest reliability of 0.86 for the athletic population.[27]

Qualitative Follow-Up

For the participants who completed the intervention, an online survey via Qualtrics was sent to their e-mail address. The purpose of the survey was to collect open-ended responses describing their experience during the intervention and follow-up with any lasting behavioral changes. The open-ended questions created by members of the research team that were used for the qualitative follow-up survey are provided in Table 1.

Experimental Procedures

Baseline Measures and Group Allocation

The participants provided demographic and baseline information during the initial session to determine eligibility and informed consent process. The baselines measures included all psychological measures (CESD, AD-ACL, CSSS, and BRS) and a performance & recovery measure (ASSQ). The participants were then randomly assigned into 2 experimental conditions: control and intervention. Participants in the control group did not receive the 4-week HRV biofeedback intervention but were asked to complete the data collection for the main outcome measures. The participants randomly assigned to the intervention group received the 4-week HRV biofeedback intervention.

Intervention

Participants in the intervention group were asked to attend 4 intervention sessions which were held weekly for 4 weeks. Each session occurred in the athletic training facility at the local college/university and lasted 10 - 15 minutes. During each intervention session, the HeartMath Institute self-regulation techniques were taught, reviewed, and practiced with the participants by a licensed mental healthcare provider trained in the HeartMath techniques. The overall goal for self-regulation techniques is to help establish a new psychological baseline, resulting in sustainable perceptual and behavioral changes. During the first intervention session, participants learned the Heart-Focused Breathing Technique™ and the Quick Coherence Technique™. The following week, participants learned the Heart Lock-In Technique™, and the Coherent Communication Technique™ in addition to reviewing the previous week's content. The third week was the last week individuals learned new concepts and the techniques, the Freeze Frame Technique™ and Attitude Breathing Techniques™. The last week of the intervention was used to review all the concepts learned. Table 3.5 (supplemental) provides detailed information on each of the intervention techniques. Each week, student-athletes were asked to use the HeartMath Inner Balance™ mobile application to practice the techniques learned during the intervention sessions. Prior to each practice the student-athlete had a "at rest" heart rate reading with the Inner Balance™ sensor that clipped onto their earlobe for 2 minutes and were asked to report their perceived recovery. After the "at rest" measure was obtained, the student-athlete was asked to practice the techniques learned for 5 minutes. The techniques were repeated after practice and participants were asked to report their perceived performance after each practice. For the duration of the 4 weeks, the participants

were asked to practice the techniques and engage in the coherence training before and after practice. After the 4-week intervention, participants in the intervention group were asked to complete a survey on their experience during and after the intervention. Participants were encouraged to provide thorough and detailed answers. Figure 3.1 provides a detailed study procedure flow chart.

Statistical Analysis

Quantitative Analysis

We used SPSS statistical software (Version 26; SPSS Inc. Armonk, NY) with an alpha set at $P < 0.05$ for all analyses. A priori power analysis was conducted using G*Power statistical software (version 3.1.9.2., Heinrich Heine University, Dusseldorf, Germany). Using a large effect size at .07, the power calculation indicated a sample size of 14 total participants for each group was needed with estimated power being 0.90. However, a sample size of 14 total participants (7 per group) is comparable to previously published studies examining heart rate biofeedback programs ranging from 14 to 20 participants per group.[8,15,17] We performed basic descriptive statistics to examine the demographic information (e.g., height, weight, age, body mass index (BMI), academic status, etc.). A 3 (Time: "at rest", pre-practice, post-practice) x 4 (Week average: week 1, week 2, week 3, week 4) repeated measures ANOVA was independently conducted to examine differences between time ("at rest", pre-practice, post-practice) and weekly coherence average (week 1, week 2, week 3, week 4) for coherence scores. A 2 (treatment group: intervention, control) x 4 (Week: week 1, week 2, week 3, week 4) repeated measures ANOVAs were independently conducted to examine differences between treatment group (intervention vs control) and week (week 1, week 2, week 3, week 4) for performance, resilience, and

recovery. For the psychological variables, 2 (treatment group: intervention, control) X 2 (Time: pre-intervention, post-intervention) repeated measures ANOVAs were independently conducted to examine differences between treatment group (intervention vs control) and time (pre-intervention vs post-intervention) for CESD, AD-ACL, CSSS, and the ASSQ sleep score.

Qualitative Analysis

The participants in the intervention group (n = 6) completed the open-ended response survey to provide their lived experiences during and following the study. All data were downloaded from Qualtrics (Qualtrics, Inc., Provo, UT) and independently read by two researchers (SRW, ZKW) with experience in qualitative research. To analyze the qualitative data and ensure trustworthiness, researchers used multiple analyst triangulation and an external reviewer.[28] To conduct this, the participants names were removed and replaced with a pseudonym. The researchers then followed a modified consensual qualitative research process by which both researchers extracted overall themes. Then, the two researchers met and coded the responses from all 6 downloaded survey transcripts to identify any subthemes. The process continued with each researcher checking the other to peer review the work of the other. During the peer review, minor coding discrepancies were noted and sent to a third researcher (TTM) who served as an external audit for the qualitative analysis. The external audit also confirmed the overall themes and subthemes, as well as the coding completed by the two initial researchers to ensure trustworthiness.[29,30] After completion of the analysis and audit, we confirmed consensus on the coding and extracted supporting quotes.

Results

Demographics

Initially, 15 participants were assessed for eligibility for the study, and due to a current injury, one was removed from participation. Fourteen student-athletes were randomized into the intervention (n = 6) and control (n = 8) groups. One participant from the control group dropped out of the study after 1 week, therefore 13 participants were included in the final analysis (Figure 3.2). All demographic data, including pseudonyms is presented in Table 3.2. The pre-test data was screened for naturally occurring differences between the intervention and control groups using independent t-tests to determine if onetime variables needed to be controlled as a covariate in subsequent analyses. Results indicated there were no significant differences ($P < .05$) precluding the need to control for time 1 data in subsequent 2x4 ANOVAs with repeated measures on the last factor. Given the sample size and required power, controlling for time 1 data was deemed inappropriate; covariate control is recommended in subsequent research.

Coherence

A 3x4 repeated measures ANOVA with a Greenhouse-Geisser correction determined that there were no significant interactions between coherence scores for "at rest", pre-practice, and post-practice ($F(1.025, 11.280) = 4.463$, $P = .057$, $N^2 = .289$), for coherence scores by group (intervention vs control) ($F(1.025, 11.280) = 4.563$, $P = .055$, $N^2 = .293$), for time ($F(1.129, 12.422) = 1.004$, $P = .347$) or for time by group ($F(1.129, 12.422) = 1.039$, $P = .388$, $N^2 = .086$). Additionally there were no significant interactions for coherence scores by time ($F(1.092, 12.422) = 1.092$, $P = .377$, $N^2 = .090$) or for coherence scores by time and by group ($F(1.092, 12.422) = .948$, $P = .358$, $N^2 = .079$). The

test between subjects indicates a significant main effect ($F(1,11) = 108.43$, $P = .026$, $N^2 = .377$). Pairwise comparisons determined a significant difference between "at rest" and pre-practice ($F(1,11) = 6.643$, $P = .040$) and between "at rest" and post-practice ($F(1,11) = 6.643$, $P = .00$). There was not a significant difference between pre-practice and post-practice scores ($F(1,11) = 6.643$, $P = .128$). Pairwise comparisons also indicate significant differences between weeks 1 and 2 ($F(1,11) = 6.643$, $P = .025$) and between weeks 1 and 3 ($F(1,11) = 6.643$, $P = .016$).

Psychological Variables

There were no significant differences for CESD scores by time ($F(1,11) = .022$, $P = .884$, $N^2 = .002$) or scores by groups ($F(1,11) = .000$, $P = .991$, $N^2 = .000$), however there was a significant difference between groups ($F(1,11) = 5.890$, $P = .034$, $N^2 = .349$) with means increasing from pre to post. For the AD-ACL energy dimension, no significant differences in means were indicated for time $F(1,11) = .243$ $P = .632$) and an interaction ($F(1,11) = 4.753$, $P = .052$) was found, whereas in the AD-ACL tension dimension, there was no significant differences for time ($F(1,11) = .313$, $P = .587$) nor groups ($F(1,11) = .022$, $P = .886$). When comparing the difference in mean for the energy and tension dimensions, no significant differences were found within subjects($F(1,11) = .510$, $P = .490$) or subjects by groups ($F(1,11) = 1.120$, $P = .313$) and no between subject differences ($F(1,11) = 5.847$, $P = .630$) were found. When examining stress, no significant differences within subjects for stress scores ($F(1,11) = .023$, $P = .883$, $N^2 = .002$) or stress scores by group($F(1,11) = .204$, $P = .660$, $N^2 = .018$). Additionally, for stress between subjects, significant differences were found for groups ($F(1,11) = 5.597$, $P = .037$, $N^2 = .337$). When examining the difference of weekly resilience scores, there were no significant differences

found for the scores ($F(1,11) = .841$, $P = .379$, $N^2 = .071$) or for the score and group combination ($F(1,11) = 1.649$, $P = .225$, $N^2 = .130$). There also were no differences between groups for the weekly resiliency scores. All means and standard deviations are found in Table 3.4.

Performance and Recovery

No significant differences were found for weekly average recovery scores ($F(2.300, 25.301) = 1.290$, $P = .296$, $N^2 = .105$) or recovery by group ($F(2.300, 25.301) = 1.968$, $P = .156$, $N^2 = .152$). There were no significant between subject differences for group ($F(1,11) = 1.023$, $P = .333$, $N^2 = .085$). As for weekly performance ratings, significant differences were found by time ($F(1.984, 21.824) = 4.178$, $P = .029$, $N^2 = .275$), but not for performance ratings by group ($F(1.984, 29.028) = 1.251$, $P = .306$, $N^2 = .102$). No significant between subject differences were found for group ($F(1,11) = .049$, $P = .829$, $N^2 = .004$). There were no significant differences found for sleep scores by time ($F(1,11) = .052$, $P = .823$, $N^2 = .005$), or by group ($F(1,11) = .052$, $P = .823$, $N^2 = .005$). When examining between subject differences, a significant difference was found ($F(1,11) = 15.489$, $P = .002$, $N^2 = .585$). All means and standard deviations are found in Table 3.4.

Qualitative Themes

Three major themes and 7 subthemes emerged from the data. The 3 major themes included 1) *Breathing techniques*, 2) *Experience*, and 3) *Effects*. The subthemes that emerged from the data included, 1) Experience: Positive, Visual Appeal, Novice, Negative, 2) Effects: Tranquility, Improvements in focus, and Neutral. Each of these themes are explained below and supported by participant's responses. All participants were given pseudonyms to protect their identity.

Theme 1: Breathing Techniques

Participants described their experience with the intervention through the various breathing techniques learned in the duration of the intervention and use of the Inner Balance application. Lucy recalled that the experience "was when you would breathe in for five seconds and then out for five seconds. It was where you focused on the inner heart and connected your breathing your inner self." Which was also confirmed by Kelly, when she discussed "focus breathing in your heart, stay focused do not wander mentally, breath in for 5 seconds and out for 5 seconds." The emergent theme of breathing techniques was referred to by participants throughout the survey in response to dealing with daily stressors. Jenny described the breathing techniques to have "helped me be more conscious of my breathing".

Theme 2: Experience

The participants discussed how they experienced the intervention and use of the Inner Balance application. The major theme of experience was broken down into subthemes based on the responses given. Each subtheme (positive, visual appeal, novice, negative) is described and supported by participant responses. Overall, all but one participant had described a positive experience when discussing the intervention, the application, and benefits of the breathing techniques. When recounting their experiences and how the individuals felt during the intervention, Kate mentioned that "it was interesting learning about the different breathing techniques to also learn about how to best cope with stress." As the participants discussed their use of the application, 2 participants noted the application was easy to use, and Becky specifically stated, "I think it was pretty cool." The participants were asked about lasting benefits since the study had ended, 2 participants

noted a simple “yes”, and Lucy mentioned that, “while I haven’t done the techniques very often, when I do them, the benefits still last and are the same as they were during the study.” When further examining effects of the study on performance, recovery, and schoolwork, Becky specifically stated that “it has made my recovery faster.”

Participants had the option to use different screens during the intervention based on their own preference. When asked about what the participants specifically remember about the application, 3 participants mentioned use of the page with a graph. Lucy stated, “I like the graph that showed you how you were doing on the techniques. It made it easy to see if you could improve on your breathing and how to improve for the next time.” This was echoed by Megan and Kelly, who also used the graph feature on the Inner Balance application. Megan specifically liked, “the page with the charts and the dot that went up and down,” and Kelly used, “the graph and numbers.”

When describing their experience, participants provided results that indicated a novice level of ability, whether it was with breathing or with the application itself. Novice experience seems to show an early stage of learning for the participants. When asked to describe what the experience was like and how they felt during the intervention, Becky stated, “I felt awkward because I have never sat down and focused on my breathing before.” Megan further described her experience with the application as, “the Inner Balance app just gave me my results, most of which I didn’t fully understand.” The participants were asked their thoughts on the device and system overall, and Kelly indicated that, “I paid more attention to trying to get my numbers up than actually breathing.”

Another subtheme that emerged was a negative experience during the intervention that was shared by 2 participants. When describing their experience, Kelly indicated, “for

me personally the breathing exercises did not work so it felt like a burden to keep going," and "I tried to incorporate the techniques in the first 2 weeks however they didn't prove to be beneficial for me so I stopped doing them outside of the study." For the same questions, Megan echoed that response and felt, "annoyed when we had to come in early and stay when in a hurry."

Theme 3: Effects

In describing their experience of the intervention and application, effects of the intervention emerged as a major theme in their responses. Within the major theme of effects, 3 subthemes emerged including, tranquility, improvements in focus, and neutrality. As participants described the effects of their experience, a tranquil or sense of calmness was noted 20 times by participants, an improvement in focus 8 times, and a neutral feeling 17 times. Each subtheme will be further described and supported by participant responses.

Tranquility refers to a sense of peace or calmness reported by the participants. Tranquility was shown by all participants in at least one of their responses discussing their experiences. Lucy stated, "During the sessions I did feel more relaxed and at ease than the days when I did not use the breathing techniques." It was also alluded to by Kate, when she mentioned, "it helped me relax sometimes after practice." When asking about the impact of self-regulation techniques on schoolwork, Becky noted, "it made schoolwork a bit less of a headache, so less stressful." A sense of tranquility was also described by Becky, "I decided to incorporate the techniques into my daily routine to see if they actually could work to help with some of my stress and it did."

As part of the effects theme, improvements in focus emerged as a common effect noted by participants. Four out of the six participants referred to an improvement in focus

as a benefit from the intervention. Lucy discussed, “I was much more focused on my breathing during these sessions than what I usually do. During these sessions, I became more aware of how bad my breathing was when I was not using the techniques.” In agreement with Lucy, Jenny also stated, “the techniques have helped me be more conscious of my breathing.”

Another subtheme of effects was neutral, or the feeling of not positive nor negative effects. In the subtheme of neutral, participants indicated no change or difference with the intervention. All participants but one indicated no change or difference in at least 1 of their responses to our questions. Jenny shared, “[the techniques] did not really affect my sport performance because I already had my own breathing techniques.” When discussing implementation of the self-regulation techniques into their daily lives, Kate stated, “I didn’t really think about [the techniques] because I already have my own way of self-regulation”, and Megan echoed that by saying, “I was already using most of these techniques before, this study was just a reminder. I use them plenty during the day.”

Discussion

Mental and physical wellness as described in the introduction is a topic of discussion and interest within collegiate athletics. The aim of the pilot study was to determine if a 4-week biofeedback heartrate intervention would improve coherence, psychological and performance variables in student-athletes with a secondary aim to describe the experience of the student-athletes that were in the intervention group. However, the results of our pilot study demonstrated a 4-week intervention focused on breathing techniques was positively accepted by the student-athletes, even though statistical significance was not achieved for all measures.

Coherence

Increased order and harmony in psychological and physiological processes are defined as coherence, also more commonly known as an optimal state of function. Through validated self-regulation techniques, individuals are able to experience mental clarity and improved function.[19] The purpose of the 4-week intervention was to introduce the self-regulation techniques to the student-athletes and each week participants would practice these techniques prior to and after team practice sessions. We hypothesized coherence scores given through the Inner Balance mobile application would improve for the individuals practicing the self-regulation techniques each day. Contrary to our hypothesis, there were no difference between the control or intervention groups for "at rest", pre-practice, or post-practice coherence scores, however comparisons did indicate differences between scores for "at rest" and pre-practice and for "at rest" and post-practice. While insignificant, the control group had consistently lower scores than the intervention group. The control group consistently stayed within the coherence categories of beginner to good, while intervention group ranged from very good to excellent through the 4 weeks. No change in coherence scores also contradicts previous findings demonstrating changes not only in heart rate but also brain activity (i.e., Electroencephalography), when utilizing self-regulation breathing techniques over a span of 5-week period.[17,31] Changes and improvements in heart rate and brain activity demonstrate an increase in coherence and a shift into a more optimal state of functioning.[11] No change in the scores from our pilot study could be due to a novice ability in learning the self-regulation techniques. Three out of the six intervention participants noted feeling "awkward' or not fully understanding the Inner Balance application. It is possible that better understanding of the self-regulation

techniques or application and remembering their steps would help improve individual coherence scores.

Additionally, during the intervention time fame, post-practice coherence scores were obtained at the student-athlete's location of practice where they focused on their breathing techniques. While the environments were generally quiet, it is possible participants became distracted, lost focus, or were concerned on about their performance of the day. Prior research examining coherence conducted their sessions in a researcher's office or in a quiet environment at home, and not part of their normal everyday routines.[19,31] We encouraged our student-athletes to learn self-regulation techniques and practice throughout their daily activities and by doing so, supported them to create a routine of practicing the techniques they could implement into their routines. The setting allowed the student-athletes to realistically practice self-regulation techniques as if they would do on their own. A few of the participants already had breathing techniques incorporated into their daily lives, and others stated, "they decided to use the self-regulation techniques into their daily routine to help with their stress."

Psychological Impact

Student-athletes experience signs and symptoms of mental illnesses (e.g., depression, stress) comparable to that of typical collegiate students.[32,33] There is a need for interventions to help reduce signs and symptoms and help student-athletes learn techniques to safely and effectively manage their mental health. With success in emWave and HeartMath self-regulation techniques being used to reducing anxiety in nursing students [34] and stress in collegiate students,[34,35] it was hypothesized a similar intervention would benefit the student-athletes and reduce reported signs and symptoms for depression,

balance arousal levels, lower stress ratings, and increase resilience. Our results revealed no significant differences between the control and intervention group for depression, stress, and resiliency scores. The intervention group had a large variance for the depression scores that stayed relatively consistent through the 4 weeks of the intervention. No change in depression scores can possibly be attributed to pre-existing signs and symptoms of depression, injuries during the intervention, or poor sport performance through the same timeframe.

HeartMath describes improvement in energy as a shift in emotional stability within those utilizing self-regulation techniques.[19] The adjectives peppy, energetic, lively, full of pep, and activated are used to represent momentary states of arousal activation (AD-ACL).[21] The results identified individuals in the both groups increased their energy states, however the control group had a higher energy score. With a small increase in the energy dimension, it is possible a shift in emotional stability may have occurred in the intervention participants, however we cannot be certain without changes in coherence scores. When examining the other spectrum of the arousal dimensions, the tension dimension remained consistent between the two groups, and while insignificant the intervention group had higher scores of tension. Activation of arousal has not been previously studied in student-athletes with use of biofeedback and self-regulation techniques, however it may warrant further examination as a momentary arousal state and possibly demonstrate a shift in emotional stability and heart rhythm pattern.

Perceived stress was also examined; while there were no significant changes across the 4 weeks, results indicate stress levels stayed consistent for both groups. The stress levels were similar to previous research on nursing students, that demonstrated stress levels

remained consistent through five weeks with the use of biofeedback and self-regulation techniques.[34] It is possible consistent stress with both groups can illustrate that all of the participants were experiencing some stress during the timeframe of the intervention. Incoherent heart rhythm patterns are associated with emotions of stress, frustration, anger, and anxiety.[19] With continuous levels of stress, coherence scores would also remain unchanged. While perceived stress did not significantly change during the intervention, participants in the intervention group did discuss effects from the self-regulation techniques through their survey responses. It was noted individuals felt "more relaxed and at ease than on the days when I did not use the breathing techniques", and schoolwork seemed, "less of a headache, less stressful". Effects may have been felt at the time of the intervention but was not reflected in the survey at the end of the intervention.

The ability to adapt, maintain, or regain positive psychological health is thought to be resilience. Resilience allows individuals to overcome and positively adapt to stressful situations and choose effective stress management techniques.[36] Our results indicated resilience scores did not improve with the intervention, rather stayed consistent. Although insignificant, the intervention group had a slight increase in resilience scores. Three of the six intervention participants reported already having breathing techniques to use during stressful situations. Their scores may have not improved by focusing on other self-regulation techniques or stayed the same because they already had some exposure to stress management through other breathing techniques.

Performance and Recovery

Performance is complex and can easily be affected by inadequate sleep or recovery. Previous research has examined biofeedback and HRV within student-athletes specifically

to enhance performance.[18] While their results indicated physiological changes in HRV, the self-report measures were not clinically significant.[8] Our self-report measures for recovery, performance and sleep were similar. It was anticipated self-reported recovery would improve over time with use of self-regulation techniques and shifting into a coherent state after practices. However, even with no significant changes demonstrated in the quantitative data, one participant specifically stated, "it has made my recovery faster."

Furthermore, student-athletes rated their performance over the 4-week period. Prior research has indicated an improvement in performance and focus for golfers, volleyball and basketball players, and long-distance runners.[16] While performance scores were not significant for the two groups, participants in the intervention group discussed improvements in their focus. It was supported when participants stated, "I was much more focused on my breathing during these sessions than what I usually do. During these sessions, I became more aware of how bad my breathing was when I was not using the techniques."

Sleep is a vital requirement for improvements in recovery and performance. Deficits in sleep quality may be detrimental to adequate recovery and sport performance. There was not a significant change in sleep quality when examining the two time points or when examining the group and time comparisons. When examining the sleep scores, the control group started with a lower sleep score than the intervention group. However, both groups fall into the mild to moderate sleep problem category. Both groups would possibly benefit from sleep recommendations that were not included in this intervention.[27]

Limitations and Future Research

While the current study is one of few implementing a mental health intervention for student-athletes using self-regulation techniques to help manage mental health signs and symptoms, it is not without limitations. First, the use of self-report questionnaires for psychological constructs are widely used and reliable. While self-report data has been deemed reliable, it is unknown if the student-athletes answered truthfully or if they answered according to what was expected as a student-athlete.

Second, our study was regarded as a pilot study due to the limited sample size that was localized to one school and two sports. Prior sample size calculations revealed that we needed 28 participants, with 14 in each group. However, spring sport seasons were canceled in March 2020 when this study was conducted due to COVID-19, restricting the continuation of the study at two other universities. It is possible that the findings may have been different if the sample size was increased and if the study was not conducted during a global pandemic that may alter one's stress. Additionally, when examining pre-intervention scores for the intervention and control group, it was determined there were outliers for the CESD scores. The pre-intervention CESD scores ranged from 3 to 39, which provided a large standard deviation for the intervention group.

Lastly, participants were expected to complete the intervention after their practices which not only can affect HRV, but participants indicated they felt annoyed when having to stay after practices which also could affect their breathing practices. In addition, the intervention occurred in the middle of both seasons for swimming and lacrosse, which is not ideal for full attention and participation from the student-athletes. Conducting this study earlier in their off season or pre-season may be a better time for student-athletes to learn

self-regulation techniques that they can use for their season and managing their mental health.

Due to the scarcity of literature for student-athlete mental health interventions, there are notable future directions for research. Our study is among previous research that has examined HRV biofeedback with student-athletes, using HeartMath techniques specifically and includes areas for improvement.[15,17] First, a larger sample including males and various sports would provide powerful comparisons for gender, sport, and help determine if the intervention is effective in reducing psychological difficulties. Replication of this study would help determine the effectiveness of a four-week intervention for mental health improvement in student-athletes.

Implications for Clinical Practice

With the current data, it can be concluded that a HRV intervention with student-athletes needs further research to determine if effective for improvement in the aspects of mental health and performance. While the results did not show statistical improvement in the intervention group, the student-athletes reported a mostly positive experience with lasting effects. The ease of the self-regulation breathing techniques and use of the Inner Balance application are promising for athletic trainers, coaches, and strength and conditioning professionals to use for mental health and wellness and performance enhancement techniques.

References

1. Reardon CL, Hainline B, Aron CM, et al. Mental health in elite athletes: international olympic committee consensus statement (2019). *Br J Sports Med.* 2019;53(11):667-699.

2. Brown GT, Hainline B, Kroshus E, Wilfert M. Mind, body and sport: understanding and supporting student-athlete mental wellness. *Indianapolis, IN: National Collegiate Athletic Association.* 2014.

3. Van Raalte JL, Cornelius AE, Andrews S, Diehl NS, Brewer BW. Mental health referral for student-athletes: web-based education and training. *J Clin Sport Psychol.* 2015;9(3):197-212.

4. Gulliver A, Griffiths KM, Christensen H, et al. Internet-based interventions to promote mental health help-seeking in elite athletes: an exploratory randomized controlled trial. *J Med Internet Res.* 2012;14(3):e69.

5. Nédélec M, Halson S, Abaidia A-E, Ahmaidi S, Dupont G. Stress, sleep and recovery in elite soccer: a critical review of the literature. *Sports Med.* 2015;45(10):1387-1400.

6. Kellmann M, Bertollo M, Bosquet L, et al. Recovery and performance in sport: consensus statement. *Int J Sports Physiol Perform.* 2018;13(2):240-245.

7. Watson AM. Sleep and athletic performance. *Curr Sports Med Rep.* 2017;16(6):413-418.

8. Rijken NH, Soer R, de Maar E, et al. Increasing performance of professional soccer players and elite track and field athletes with peak performance training and biofeedback: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(4):421-430.

9. Shaffer F, Ginsberg J. An overview of heart rate variability metrics and norms. *Front Public Health.* 2017;5:258.

10. Shaffer F, Venner J. Heart rate variability anatomy and physiology. *Biofeedback.* 2013;41:13-25.

11. McCraty R, Shaffer F. Heart rate variability: new perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health risk. *Glob Adv Health Med.* 2015;4(1):46-61.

12. Castaneda D, Esparza A, Ghamari M, Soltanpur C, Nazeran H. A review on wearable photoplethysmography sensors and their potential future applications in health care. *Int j biosens.* 2018;4(4):195-202.

13. Dong J-G. The role of heart rate variability in sports physiology. *Exp Ther Med.* 2016;11(5):1531-1536.

14. Laborde S, Mosley E, Thayer JF. Heart rate variability and cardiac vagal tone in psychophysiological research - recommendations for experiment planning, data analysis, and data reporting. *Front Psychol.* 2017;8:213-213.

15. Tanis CJ. The effects of heart rhythm variability biofeedback with emotional regulation on the athletic performance of women collegiate volleyball players. *Psychology.* 2011.

16. Jimenez Morgan S, Molina Mora JA. Effect of Heart Rate Variability Biofeedback on Sport Performance, a Systematic Review. *Appl Psychophysiol Biofeedback.* 2017;42(3):235-245.

17. Dziembowska I, Izdebski P, Rasmus A, Brudny J, Grzelczak M, Cysewski P. Effects of heart rate variability biofeedback on EEG alpha asymmetry and anxiety symptoms in male athletes: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(2):141-150.

18. Jiménez S, Molina JAM. Effect of heart rate variability biofeedback on sport performance, a systematic review. *Appl Psychophysiol Biofeedback.* 2017;42(3):235-245.

19. Thurber M, McCraty R, Kabaker B, Shaffer T, Wilson B, Sawyer S. HeartMath interventions for counselors, therapists, social workers and health care professionals: establishing a new baseline for sustained behavioral change. *Boulder Creek, CA: HeartMath LLC.* 2008.

20. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1(3):385-401.

21. Thayer RE. Activation-deactivation adjective check list: current overview and structural analysis. *Psychol Rep.* 1986;58(2):607-614.

22. Thayer RE. Factor analytic and reliability studies on the activation-deactivation adjective check list. *Psychol Rep.* 1978;42(3):747-756.

23. Feldt RC. Development of a brief measure of college stress: the college student stress scale. *Psychol Rep.* 2008;102(3):855-860.

24. Smith BW, Dalen J, Wiggins K, Tooley E, Christopher P, Bernard J. The brief resilience scale: assessing the ability to bounce back. *Int J Behav Med.* 2008;15(3):194-200.

25. Laurent CM, Green JM, Bishop PA, et al. A practical approach to monitoring recovery: development of a perceived recovery status scale. *J Strength Cond Res.* 2011;25(3):620-628.

26. Hjermstad MJ, Fayers PM, Haugen DF, et al. Studies comparing numerical rating scales, verbal rating scales, and visual analogue scales for assessment of pain

intensity in adults: a systematic literature review. *J Pain Symptom Manage.* 2011;41(6):1073-1093.

27. Bender AM, Lawson D, Werthner P, Samuels CH. The clinical validation of the athlete sleep screening questionnaire: an instrument to identify athletes that need further sleep assessment. *Sports Med Open.* 2018;4(1):23.

28. Pitney WA. Strategies for establishing trustworthiness in qualitative research. *Int J Athl Ther Train.* 2004;9(1):26-28.

29. Hill CE. Consensual qualitative research (CQR): methods for conducting psychotherapy research. In: *Psychother Res.* Springer; 2015:485-499.

30. Hill CE, Knox S, Thompson BJ, Williams EN, Hess SA, Ladany N. Consensual qualitative research: an update. *J Couns Psychol.* 2005;52(2):196.

31. Deschodt-Arsac V, Lalanne R, Spiluttini B, Bertin C, Arsac LM. Effects of heart rate variability biofeedback training in athletes exposed to stress of university examinations. *PLoS One.* 2018;13(7):e0201388.

32. Wolanin A, Hong E, Marks D, Panchoo K, Gross M. Prevalence of clinically elevated depressive symptoms in college athletes and differences by gender and sport. *Br J Sports Med.* 2016;50(3):167-171.

33. Ibrahim AK, Kelly SJ, Adams CE, Glazebrook C. A systematic review of studies of depression prevalence in university students. *Psychiatry Res.* 2013;47(3):391-400.

34. Ratanasiripong P, Ratanasiripong N, Kathalae D. Biofeedback intervention for stress and anxiety among nursing students: a randomized controlled trial. *ISRN Nurs.* 2012:827-972.

35. Whited A, Larkin K, Whited M. Effectiveness of emwave biofeedback in improving heart rate variability reactivity to and recovery from stress. *Appl Psychophysiol Biofeedback.* 2014;39.

36. Litwic-Kaminska K, Izdebski P. Resiliency against stress among athletes. *Health Psychol Rep.* 2016;4:79-90.

Table 3.1 Open-Ended Survey Questions

1. Please discuss what you remember about the intervention sessions. Tell me about what you did.
2. Can you describe to me what the experience was like? How did you feel during the intervention session?
3. Tell me more about what you remember specifically on the Inner Balance application.
4. What were your thoughts about the device and system?
5. What view feature did you use on the application?
6. Please describe any positive effects or benefits from the intervention during the study?
7. Have those benefits lasted since the study ended?
8. Please describe any negatives effects or setbacks from the intervention during the study?
9. Have those setbacks lasted since the study ended?
10. Can you describe how the self-regulation techniques have impacted your sport performance?
11. Can you describe how the self-regulation techniques have impacted your recovery?
12. Can you describe how the self-regulation techniques have impacted your schoolwork?
13. As part of the study, we taught you some self-regulation techniques and encouraged you to incorporate these in your daily routine. Please discuss your decision to or not to incorporate the techniques during the study period?
14. How did you go about doing this on your own? Were you successful?
15. Over the last month since the study ended, tell me about how you have incorporated, if at all, the self-regulation techniques into your life.
16. In your opinion, what suggestions for change do you have about the intervention that would have been helpful to you during the study?

Table 3.2 Demographic information including academic status, sport and ethnicity (n=13)

		M	*SD*
Age		19.9	1.3
Height (cm)		166.3	8.7
Weight (kg)		73.3	19.0
Academic Status		*%*	*n*
Freshman		30.8	4
Sophomore		15.4	2
Junior		30.8	4
Senior		23.1	3
Sport		*%*	*N*
Lacrosse		69.2	9
Swimming		30.8	4
Ethnicity		*%*	*n*
Caucasian		53.8	7
Black or African American		30.8	4
Biracial/Two or More Races		23.1	2
Pseudonym	Sport	Academic Status	Age
Lucy	Lacrosse	Sophomore	19
Kate	Swimming	Sophomore	19
Becky	Lacrosse	Freshman	18
Megan	Swimming	Junior	20
Kelly	Lacrosse	Freshman	18
Jenny	Swimming	Senior	22

Table 3.3 Means and standard deviations for coherence and performance variables

	Control (n=7)								
	Week 1		Week 2		Week 3		Week 4		ANOVA
	M	SD	M	SD	M	SD	M	SD	F (3,33)
Baseline Coherence	1.18	.27	1.47	.36	1.50	.44	1.50	.24	.055
Pre-Practice Coherence	1.46	.35	1.30	.37	1.50	.32	1.51	.33	
Post-Practice Coherence	1.63	.39	1.55	.21	1.55	.27	1.73	.54	
Recovery	5.76	1.57	6.18	1.45	5.61	1.41	4.76	1.27	.296
Performance	5.32	1.16	6.26	.75	5.64	.52	4.64	.93	.029**
Brief Resilience	3.44	.19	2.61	.35	3.56	.25	3.61	.35	.397
	Intervention (n=6)								
	Week 1		Week 2		Week 3		Week 4		
	M	SD	M	SD	M	SD	M	SD	
Baseline Coherence	1.67	.61	1.77	.48	1.31	.34	1.55	.56	
Pre-Practice Coherence	3.50	1.09	3.05	1.20	2.25	.95	5.74	8.57	
Post-Practice Coherence	2.98	.80	2.02	.98	1.78	.57	1.73	.54	
Recovery	5.16	.57	5.09	1.49	4.64	.50	5.25	1.07	
Performance	5.29	.64	5.71	1.53	5.33	1.04	5.21	.58	
Brief Resilience	3.50	.50	3.39	.67	3.44	.59	3.72	.38	
**Significance at .05 level									

Table 3.4 Means and standard deviations for psychological variables

	Control (n =7)				Intervention (n=6)				
	Pre-Intervention		Post-Intervention		Pre-Intervention		Post-Intervention		ANOVA
	M	SD	M	SD	M	SD	M	SD	F (1,11)
CESD	10.43	5.94	10.71	4.35	19.67	12.03	20.00	7.64	.884
AD-ACL Energy	13.14	2.79	11.14	3.67	9.00	1.55	9.83	3.76	.632
AD-ACL Tension	8.00	2.08	8.57	2.64	9.50	5.24	9.83	4.02	.587
CSSS	25.29	7.91	24.29	4.96	35.17	11.92	35.67	8.91	.883
ASSQ	6.00	2.45	6.00	1.53	10.33	2.73	10.00	2.45	.823
**Significance at .05 level									
*Center of Epidemiologic Studies Depression Scale - CESD *Activation- Deactivation Adjective Check List- AD-ACL * College Student Stress Scale- CSSS *Athlete Sleep Screening Questionnaire - ASSQ									

Table 3.5 HeartMath self-regulation techniques

Technique	Focus of Technique
Heart-Focused Breathing	Reduce the impact of stress on your mind and body and reduce energy drain by going into a neutral state.
Quick Coherence	Builds on Heart Focused Breathing and allows individual to shift emotions to positive and productive ones.
Heart Lock-In	Builds on Quick Coherence and focuses on sustaining heartfelt positive emotions and coherence for longer periods of time.
Coherent Communication	Designed to improve connection and understanding between listener and speaker during communication.
Freeze Frame	Freeze frame is designed to help individuals slow down emotional reactions and make a positive shift to find new solutions to stressful or challenging problems.
Attitude Breathing	This technique focuses on emotional restructuring and refocusing by helping individuals identify undesired emotional states and identify a replacement attitude.

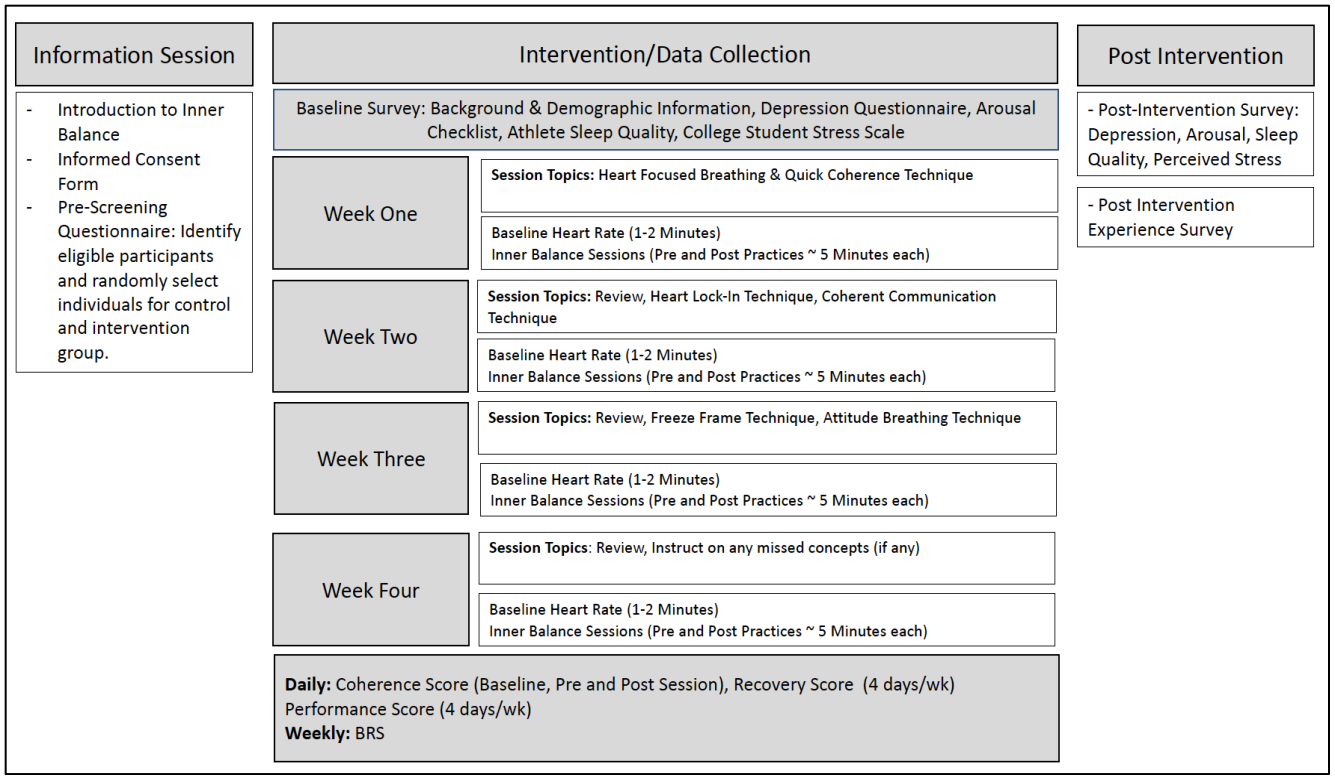

Figure 3.1. Detailed Outline of Procedures

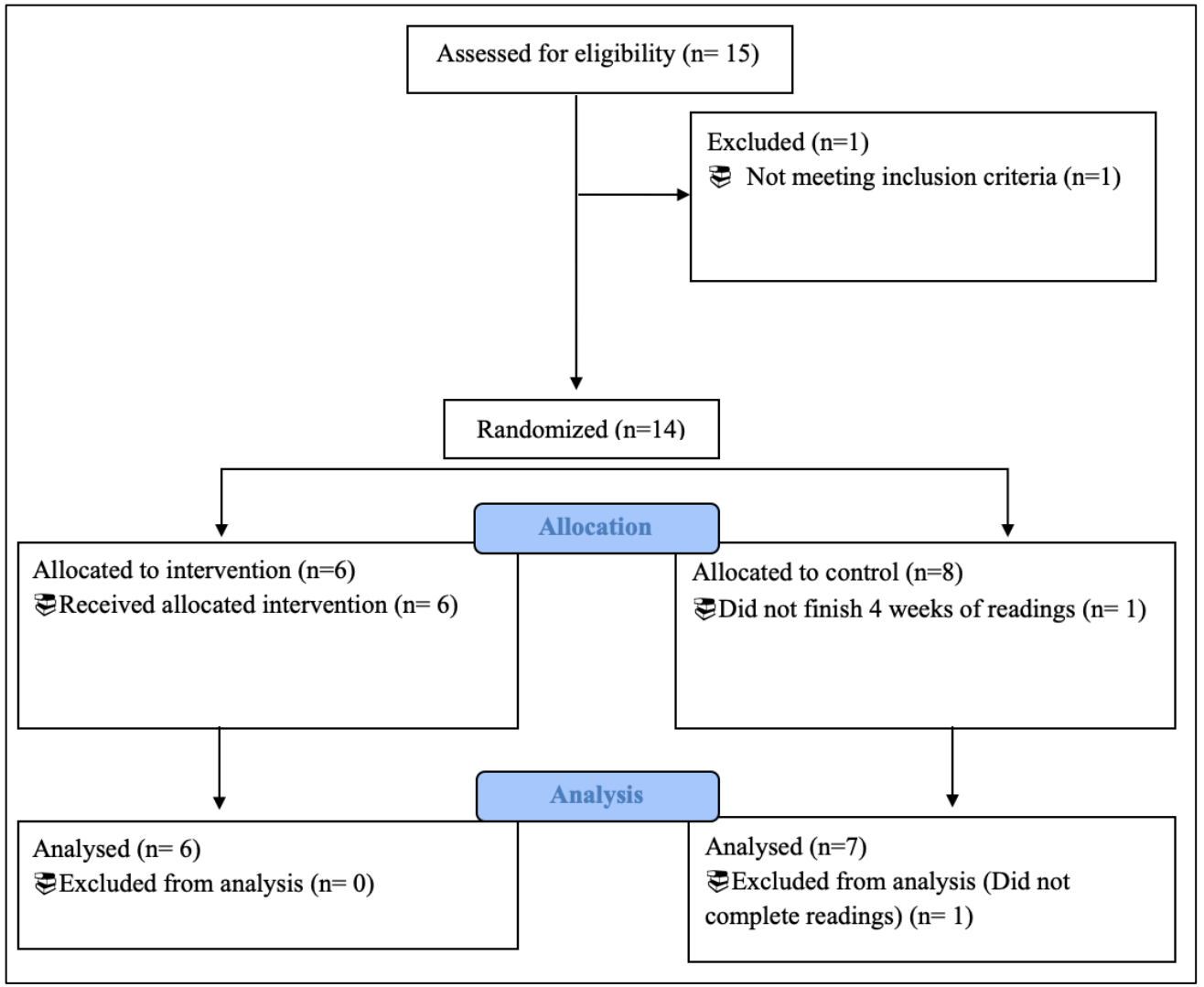

Figure 3.2. Summary of participant flow through the research protocol.

Chapter 4

Proposal

Introduction

Throughout the United States, 1 in 5 adults experience a mental disorder, with over 40 million adults experiencing a mental disorder each year. The most common mental disorders experienced are anxiety and depressive disorders.[1] These numbers include but are not limited to college students and reactions to their personal stress and responsibilities. College students above the age of 18 may be at a higher risk for developing mental health disorders due to high stress, negative life events, or significant life changes. Student-athletes also experience many of the same opportunities as general college students. They are responsible for maintaining academic and sport requirements, while holding high standards held by their coaches, teammates, and family members. Often, student-athletes are assumed to be a generally healthy population and potentially immune to mental health disorders. However, recent research has indicated that student-athletes experience a prevalence rate similar to general college students for experiencing symptoms of anxiety and depression.[2,3]

With a rise in the prevalence of suicide and mental health disorders in student-athletes, the National Collegiate Athletic Association (NCAA) has taken steps to recognize the importance of mental health and wellness for student-athletes. In 2016, the NCAA's Sport Science Institute published their Mental Health Best Practices document for institutions to use as a resource for mental health and well-being.[4] In addition, research is

calling for prevention and intervention programs to help mitigate signs and symptoms of mental health disorders. Currently the focus is on prevention programs through education and educational materials (e.g., websites, interactive web-based mental health literacy programs) and does not include interventions geared to reduce depressive or anxious symptoms experienced by student-athletes.[5]

Biofeedback is a well-known modality in which individuals can visualize physiological measurements (e.g., muscle function, skin temperature, cardiovascular activity).[6] Through biofeedback individuals gain control of their physiological functions and increase awareness of their thoughts and emotions. The HeartMath Institute has extended research on the effect of heart activity on brain function by developing heart rate variability (HRV) biofeedback modalities such as EmWave™ and Inner Balance™.[7] Inner Balance™ technologies allow individuals to visualize their HRV in real time with the goal of training individuals to recognize heart rate rhythms and implement trainings into daily life. The EmWave™ technology has been previously used and researched in numerous populations, including but not limited to college nursing students and general college students for stress and anxiety.[8-10] Within these studies it was found that the use of biofeedback devices and the techniques learned decreased anxiety and maintained stress levels throughout the intervention. EmWave™ technology has also been used within the student-athlete population and primarily geared toward sport performance.[11-13] To date, research has not focused on the mental health of student-athletes as a primary focus for intervention benefits. Previous studies have eluded to a reduction in anxiety symptoms and it has been suggested the intervention may help with increasing sleep quality and decreasing the symptoms of depression and stress. Therefore, the main objective of this

study is to examine the effects of a 4-week heart rate biofeedback training intervention on mental health outcomes in current student-athletes.

Statement of the Problem

There is research identifying the prevalence of mental health symptoms in college students, and more recently student-athletes, however, there are limited studies on strategies to prevent symptoms from developing and/or intervene after symptoms have developed. Currently mental health interventions focus on education for student-athletes and coaches but do not provide feasible and transferable skills for student-athletes to learn and manage their stress and anxiety.[5] It has been suggested that biofeedback through EmWave™ technology can improve anxiety and stress in general college students; however, it is unknown if the techniques can also be beneficial for the collegiate student-athletes' mental health, performance, and recovery.[11-13]

Specific Aims and Hypotheses

Overall Hypothesis: A 4-week heart rate biofeedback intervention will improve mental health (e.g., depressive symptoms, anxiety symptoms, perceived stress, quality of sleep) and performance outcomes at two time-points (i.e., middle of the intervention, post intervention). This overall hypothesis will be tested under four specific aims.

Specific Aim 1. Examine and compare changes in psychological variables (e.g., depressive symptoms, anxiety symptoms, perceived stress) from pre-intervention, middle of intervention, and post-intervention (4-weeks) for individuals across experimental groups (control (healthy A), control (mental health counseling B), control (injured C), intervention group (healthy A), intervention (mental health counseling B), intervention (injured C).

Hypothesis 1.1. There will be a reduction of depressive and anxious symptoms and reduced perceived stress, in the healthy intervention group when compared to the control healthy group.

Hypothesis 1.2. There will be a greater reduction of depressive and anxious symptoms and perceived stress in the mental health counseling intervention compared to the mental health counseling control group.

Hypothesis 1.3. There will be a reduction of depressive and anxious symptoms and perceived stress in the injured intervention group compared to the injured control group.

Specific Aim 2. Examine changes in baseline HRV coherence scores with a 4-week heart rhythm biofeedback training program across all experimental groups.

Hypothesis 2.1. Baseline HRV coherence scores improve weekly with the 4-week heart rhythm biofeedback training program in the healthy intervention group when compared to the healthy control group.

Hypothesis 2.2. Baseline HRV coherence scores will improve weekly with the 4-week heart rhythm biofeedback training program in the mental health counseling intervention group when compared to the mental health counseling control group.

Hypothesis 2.3. Baseline HRV coherence scores will improve weekly with the 4-week heart rhythm biofeedback training program in the injured intervention group when compared to the injured control group.

Specific Aim 3. Examine changes in HRV coherence scores weekly, over a 4-week heart rhythm biofeedback training program across all experimental groups.

Hypothesis 3.1. HRV coherence scores will improve weekly with a 4-week heart rhythm biofeedback training program in the healthy intervention when compared to the healthy control group.

Hypothesis 3.2. HRV coherence scores will improve weekly with a 4-week heart rhythm biofeedback training program in the mental health counseling intervention group when compared to the mental health counseling control group.

Hypothesis 3.3. HRV coherence scores will improve weekly with a 4-week heart rhythm biofeedback training program in the injured intervention group when compared to the injured control group.

Specific Aim 4. Examine and compare changes in sleep quality from pre-intervention, middle of intervention, and post-intervention (4-weeks) for individuals across experimental groups (control (healthy A), control (mental health counseling B), control (injured C), intervention group (healthy A), intervention (mental health counseling B), intervention (injured C).

Hypothesis 4.1. The 4-week heart rhythm biofeedback training program will improve sleep quality scores in the healthy intervention group compared to the healthy control group.

Hypothesis 4.2. The 4-week heart rhythm biofeedback training program will improve sleep quality scores in the mental health counseling intervention group compared to the mental health counseling control group.

Hypothesis 4.3. The 4-week heart rhythm biofeedback training program will improve sleep quality scores in the injured intervention group compared to the injured control group.

Specific Aim 5. Examine differences in performance scores for individuals across experimental groups (control (healthy A), control (mental health counseling B), intervention group (healthy A), intervention (mental health counseling B) for one home game and one away game.

Hypothesis 5.1. Individuals in the healthy intervention group will report greater performance ratings compared to the control healthy group.

Hypothesis 5.2. Individuals in the mental health counseling intervention group will report greater performance ratings compared to the mental health counseling control group.

Specific Aim 6: Examine and compare changes in perceived recovery status scores for individuals across all experimental groups (control (healthy A), control (mental health counseling B), control (injured C), intervention group (healthy A), intervention (mental health counseling B), intervention (injured C).

Hypothesis 6.1. The 4-week heart rhythm biofeedback training program will improve perceived recovery status scores in the healthy intervention group, compared to the healthy control group.

Hypothesis 6.2. The 4-week heart rhythm biofeedback training program will improve perceived recovery status scores in the mental health counseling group, compared to the mental health counseling control group.

Hypothesis 6.3. The 4-week heart rhythm biofeedback training program will improve perceived recovery status scores in the injured intervention group, compared to the injured control group.

Literature Review

Student-athletes are college students, sharing in the same challenges and opportunities as general college students, with an additional role as an athlete. Not only are collegiate student-athletes required to maintain academic and sport requirements, but they also are held to high standards by coaches, teammates, and family members. College student-athletes are generally considered a healthy population and are often assumed to be immune to mental health disorders (i.e., depression, anxiety). Recently, prevalence research has identified a comparable rate of depressive and anxious symptoms in college students and college student-athletes.[2,3] The research in mental health for student-athletes has been increasing; however, there are limited studies examining risk factors, prevention, and intervention programs. Therefore, the purpose of this literature review is to discuss common mental health disorders (i.e., depressive disorders, anxiety disorders) that student-athletes may encounter, risk factors, prevalence rates, prevention and intervention programs and an introduction to heart rate variability for the reduction in depressive and anxious symptoms.

Depressive Disorders

The Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5) characterizes depressive disorders as disorders that share common features of sad, empty, irritable moods with cognitive and somatic changes which result in a decreased ability to function.[14] The DSM-5 addresses diagnostic criteria for 4 specific depressive Disorder; Disruptive Mood Dysregulation Disorder, Persistent Depressive Disorder (PDD), Premenstrual Dysphoric Disorder, and Major Depressive Disorder (MDD). The clinical features of disruptive mood dysregulation disorder will be presented; however, it will not

be included in the rest of the literature review as it does not pertain to college students or collegiate student-athletes.

Disruptive Mood Dysregulation Disorder

Disruptive Mood Dysregulation disorder is characterized by severe and recurrent temper outbursts in children ages 6 to 11.[15,16] These outbursts must occur 3 or more times a week for at least 1 year in multiple settings (e.g., school, home, daycare) to be considered for diagnosis. In addition, the temper outbursts are beyond the normal reaction or response to a situation.[14] For an accurate diagnosis, it is pertinent the frequency, duration, and persistence of the tantrums are recorded and assessed. This specific disorder is primarily found in children and therefore will not be included any further in this literature review.

Persistent Depressive Disorder

PDD is characterized as having a depressed mood for most of the day, most days than not and is often considered a chronic form of depression. [15,16] To be considered for diagnosis, an individual must have at least 2 symptoms present during the same period. These symptoms include poor appetite or overeating, change in sleep habits, low energy or fatigue, low self-esteem, impaired concentration or indecisiveness, and hopelessness. Furthermore, individuals must not be without symptoms for more than 2 months.[14-16] To differentiate from MDD, the individual has experienced a depressed mood for 2 years or longer.[15,16]

Premenstrual Dysphoric Disorder

Premenstrual Dysphoric Disorder is defined as affective lability (mood dysregulation), irritation, and depressive symptoms that occur in the last week of the menstrual cycle in women.[15] An accurate diagnosis requires minimally 5 clinically

significant symptoms that repeatedly occur during the pre-menstrual phase of the cycle and remit shortly after. To be considered for diagnosis, at least 1 symptom must include a disturbance in general mood, irritability, anxiety or dysphoria.[16] Additionally, individuals must report 1 of the following symptoms: trouble concentrating, anhedonia (or inability to feel pleasure), lethargy, sleep, and appetite changes, overwhelmed, and physical symptoms.[14,16] More specifically, physical symptoms include breast tenderness, swelling, joint or muscle pain, bloating, and weight gain. Furthermore, the diagnosis of Premenstrual Dysphoric Disorder is contingent upon symptoms occurring in menstrual cycles for the past year and are severe enough to cause impairment in work or social situations.

Major Depressive Disorder

MDD is defined by 1 or more major depressive episodes with an absence of mania and hypomania.[15] To be considered for diagnosis; an individual must have 5 out of 9 of the following symptoms be present during the same 2-week period. These symptoms include depressed mood, loss of interest or pleasure, changes in weight or appetite, insomnia or hypersomnia, psychomotor retardation or agitation, loss of energy or fatigue, worthlessness or guilt, impaired concentration or indecisiveness, thoughts of death or suicidal ideation or attempt. One of the 5 symptoms must include a depressed mood or loss of interest or pleasure.[14,15] There are 14 subcategories that can be included with a diagnosis of MDD. These include anxious distress, mixed features, melancholic features, atypical features, mood-congruent psychotic features, catatonia with peripartum onset, and seasonal onset.[14,15]

Measurement of Depressive Symptoms and Depressive Disorder

For an official diagnosis of a depressive disorder, individuals can seek the help of a psychiatrist, clinical or school psychologists, clinical social worker, licensed professional counselor, mental health counselor, or nurse psychotherapist. Each mental health professional listed above have been trained to diagnose mental health disorders; however, not all can provide psychotherapy or prescribe medications. To assist with the assessment, semi-structured and structured interviews, and self-report measures can be used in addition to the DSM-5 guidelines, and clinical judgment. Commonly in research, semi-structured and structured interviews and self-report measures are used to provide an estimate on prevalence of symptoms for the desired sample. Research on depressive symptomology prevalence in college students typically include the following self-report measures: Hospital Anxiety and Depression Scale,[17] Depression Anxiety Stress Scale (DASS),[18] Beck Depression Inventory,[19,20] Center for Epidemiologic Depression Studies (CES-D),[21] and the Patient Health Questionnaire-9.[22] These self-report measures have been validated and are frequently used in research.

Measurement of Depressive Symptoms in Student-Athlete Research

The instruments used to assess depressive symptomology in collegiate student-athletes include the Beck Depression Inventory (BDI), CES-D, Personality Assessment inventory subscales, and Patient Health Questionnaire (PHQ-9). Primarily the BDI and CES-D are used for prevalence rates and assessing depressive symptomology after injury.[2,23-27] The BDI is a validated screening instrument that was designed to evaluate the presence and intensity of cognitive, affective, and somatic symptoms of depression.[28] This standard rating scale consists of 21 items and has been found to have high internal

consistency in psychiatric (.86) and non-psychiatric (.81) populations.[20] The CES-D is another instrument used to assess the frequency of depressive symptoms. The CES-D has been validated for the general, adult population with good internal reliability of .85.[21] There are 20 items to assess frequency (e.g., rarely or none of the time, most or all of the time) of depressive symptoms over the past week. A score of 16 or greater indicates a risk for depression. There are various screening tools validated and used for assessing depression risk in research; however, it is difficult to compare prevalence results and make assumptions based on the findings.

Etiology of Depressive Disorders

The etiology of depressive disorders can be a combination of factors from biological, psychological, social, and sociocultural contexts. Development of depressive disorders generally begins in adolescence and transitions through adulthood. This timeframe places college students at risk based on age group alone. Dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis has an essential role in the biological development of depressive disorders. The HPA axis activates with stressful situations, and once activated, the body prepares for immediate action and is in a "fight or flight" mode.[29,30] Once the HPA is enabled, higher levels of processing from the brain must return it to normal. With excessive exposures to stress and triggers, the neural connections associated with the HPA axis become strengthened, which can increase cortisol levels and increase an individual's susceptibility to physical and mental health disorders.[31] In addition to the HPA axis, there are neurotransmitters responsible for the etiology of MDD. There is no one neurotransmitter in the brain that is solely responsible for MDD; however,

Serotonin, Norepinephrine, and Dopamine have all been linked to the etiology and development of MDD.[31]

The psychological factors associated with depressive disorders have a significant impact on the etiology of depression in younger individuals, where a combination of heredity and psychological factors significantly impact adolescents and adults. The psychological dimension of depressive disorders is based on two main components: behavioral and cognitive factors that play a role in the development and etiology of depression. Within the behavioral component, it has been found that stressful situations and circumstances increase the risk of depressive disorders.[32] These situations include childhood adversity, perceived stress, job loss, death of a family member or friend, injury, or sickness.[32,33] Typically, social reinforcement is insufficient, furthermore causing individuals to withdraw from social interactions, decreasing their self-confidence, and exacerbating their depressive symptoms.[30] Within the cognitive component, the processes behind how people think, negative thought processes, damaging self-views, pessimism, and helplessness are critical components to the development of depressive symptoms.[33] Negative thinking patterns or processes affect emotional reactions and often cause exaggerated or irrational reactions to things occurring around them. The other areas of etiology for depressive disorders include social and sociocultural risk factors, including lack of social support or disruption of social support, ethnic or racial discrimination, and low socioeconomic status.[30]

Depressive Disorder Risk Factors

There are specific risk factors associated with depressive disorders. These risk factors can include neuroticism or negative affectivity (negative emotions), stressful life

events, adverse childhood experiences, or significant life changes may predispose individuals.[32,33] Likewise, family history and genetics may place someone at risk for depressive disorders.[33] Other factors to consider for depressive disorders, is experiencing a chronic or disabling medical condition or developing another mental health condition in addition to the depressive disorder (e.g., anxiety, borderline personality disorder). Risk factors for depressive disorders in the general college population are like that of college student-athletes.

In addition to the risk factors that college students face, student-athletes also face additional stressors that may put student-athletes at a higher risk for depressive symptoms. Some specific risk factors for depressive symptoms in collegiate student-athletes include genetic factors (e.g., family history), low social support, competitive failure, pain, sports injury, career termination, or a decline in performance.[26,34,35] Early retrospective research indicated that student-athletes who experienced a musculoskeletal injury were at a higher risk for depressive symptoms than non-injured student-athletes.[36] In another study, Leddy et al.,[37] used a prospective research design to examine depressive symptoms after an injury occurred. Findings indicated that over half of the athletes (51%) who were injured during the study reported depressive symptoms ranging from mild to severe.[37] More recently, using semi-structured interviews and the CES-D, it was found that depressive symptoms were present one week after injury, and symptomology was persistent one month after injury when compared to healthy controls.[38] While previous research has identified those who were at risk for depressive symptomology after a musculoskeletal injury, Li et al.,[24] examined depressive symptoms at the beginning of the season and followed the student-athletes prospectively through 4 seasons. Those who reported preseason depressive

symptoms did not have an increase in injury risk; however, males were more likely to become injured in a game.[24]

A sports injury has been linked to an increased risk for depressive symptoms after an injury; however, it is still not well understood if prior depressive symptoms place student-athletes at a higher risk for depressive symptoms after an injury. Moreover, there are mixed findings on the injury type and the link to depressive symptomology. Prospectively examining depressive symptomology before and after a sports injury would help understand the relationship between depressive symptomology and injury type and risk.

Just as musculoskeletal and orthopedic injuries are associated with an increased risk for depressive symptoms, concussive injuries have also been linked to depressive symptomology. The symptoms of a concussion can overlap with and exacerbate depressive symptoms. There is a growing amount of literature examining mental health disorders with a concussion. Recent systematic reviews support that concussions may predispose student-athletes to depressive symptoms in the acute and chronic stages.[39,40] In a study of National Collegiate Athletic Association (NCAA) Division I student-athletes, depressive symptoms in concussive participants significantly increased after a concussion and returned to baseline one to three months later.[41] Additionally, recurrent concussions in retired professional football players were found to be associated with an increased risk of depressive symptoms.[42,43] There is clear evidence that concussive symptoms pose a threat for depressive symptoms in student-athletes both in the acute and chronic stages. After student-athletes sustain a concussion, there should be careful monitoring for depressive symptoms, and the return protocol should also address a return to baseline of depressive

symptomology. Currently, the National Athletic Trainers' Association (NATA) position statement on management of sport concussion only mentions depressive symptoms as a possible mediator of current concussions and a potential long term consequence.[44]

Another risk factor for depressive symptoms in student-athletes is career termination. In a recent review, researchers identified career termination as a life transition that can cause psychological distress.[2] Weigand et. al.,[45] hypothesized that changes in their lifestyle and a loss of personal identity might put former athletes at an increased risk for depression. However, the opposite was found, and current student-athletes were at a higher risk for depressive symptoms than former athletes.[45] This study does not account for an abrupt disruption in athletic identity due to an injury. Therefore, there may be an increased risk of psychological distress and depression after a loss of athletic identity, including an increased risk for suicide.

Prevalence of Depressive Disorders

A National Comorbidity Survey Replication in 2001-2003 reported an estimated prevalence of PDD and Premenstrual Dysphoric Disorder. These prevalence rates were based on diagnostic interview criteria through a national survey conducted between February 2001 and April 2003, with a response rate of 79%. Based on diagnostic interview data the prevalence for PDD in adults, was at an estimated 1.5% of U.S. adults had PDD in the past year, with a higher prevalence associated with females (1.9%) compared to males (1.0%). More recently using face to face interviews, the 12-month prevalence for PDD in the United States is approximately 0.5% with a lifetime prevalence of 0.9%. The 12-month prevalence for Premenstrual Dysphoric Disorder is between 1.8% and 5.8%, with higher estimates based on retrospective recall. In estimates using prospective daily

ratings, the prevalence is approximately 1.8% for individuals without functional impairment and 1.3% with functional impairment.[46,47]

The national prevalence data for MDD from the years of 2013-2016, used data from the National Health and Nutrition Examination Survey (NHANES). NHANES is a cross-sectional survey that monitors the health and nutrition status of the U.S. population. Trained interviewers administered the PHQ-9 during a private interview in a mobile examination center. The prevalence rates from this survey indicated, 8.1% of American adults over the age of 20 had depression in two weeks, with women (10.4%) twice as likely to have depression compared to men (5.5%). Specifically, in college-aged individuals, the prevalence rate of depressive symptoms in a multi-campus examination using the PHQ-9 was 17.3%, with females reporting a significantly higher depressive symptom prevalence than males.[48] In a systematic review examining depression prevalence in university students, the prevalence ranged from 10-84.5% with a weighted prevalence of 30.6%.[49] This systematic included 24 studies of college students, 23 studies that used 8 different self-report depressive symptom scales, and one that used a diagnostic interview. In the study that used a diagnostic interview, the prevalence rate was 10.3% among medical students.[49]

Reporting and comparing prevalence rates for depressive symptoms in student-athletes and the general population is confounded by instrument differences to assess mental health symptoms and disorders, and the variation for how studies found prevalence rates. There is a distinct difference when using self-reported symptom instruments or physician diagnosed disorders for actual prevalence rates. Specifically, in the student-

athlete population, the prevalence of depressive symptoms is found primarily using self-report instruments.

The prevalence rates for PDD and premenstrual dysphoric disorder symptoms in student-athletes are largely unknown, and therefore, prevalence rates will not be provided. MDD is the most commonly assessed depressive disorder in the student-athlete population. The prevalence rates of depressive symptoms found in previous research are found using self-report instruments rather than with a diagnostic interview or physician diagnosis. The prevalence of depressive symptoms in student-athletes ranges from 15.6%[50] to 30.1%[51] using the BDI and CES-D. Overall, depressive symptom rates are often higher in female student-athletes,[3,23,51] who are more likely to report depressive students.[52] Regarding academic status, undergraduate freshman and underclassmen have been found to report higher rates of depressive symptoms compared to older student-athletes.[23,51] Different sports are associated with different depressive symptom prevalence rates. Depressive symptoms may be more rampant in individual sports compared with team sports.[3] For example, track and field athletes had the highest prevalence of depressive symptoms compared to lacrosse athletes in a study that examined both team and individual sports.[3] In summary, only two studies examined depressive symptom prevalence rates by academic status,[23,25] two by sport type,[3,23] and three examined depression and injury risk.[23-25] More research examining prevalence rates across various academic statuses, sports, and gender would provide insight into specific groups that can be targeted for prevention programs in sport.

Anxiety Disorders

The DSM-5 characterizes anxiety disorders as disorders that include excessive fear and anxiety and behavioral disturbances. Fear is an emotional response to a real or perceived threat that can cause excessive fear or anxiety about a situation, whereas the definition of anxiety is the anticipation about a future event or threat.[14] Anxiety is further distinguished by state or trait anxiety. State anxiety is an individual's response to danger or threatening demands, whereas trait anxiety reflects the stable differences in an individual's response to the anticipation of threatening situations.[53] The anxiety disorders can be differentiated from one another with the type of situation, object, or circumstance that elicit anxiety, fear, or avoidance behaviors. Anxiety disorders included in the DSM-5 include separation anxiety disorder, selective mutism, specific phobia (SP), social anxiety disorder (SAD), panic disorder (PD), agoraphobia, and generalized anxiety disorder (GAD). Within this literature review, the clinical features of separation anxiety disorder and selective mutism are discussed, but not included in the rest of the review due to their presence in childhood.

Separation Anxiety Disorder

Separation anxiety disorder is defined as an individual's excessive fear or anxiety with separation from those to whom the individual is attached. Developmentally, the anxiety exceeds what is normally expected. With any separation or anticipation of separation, there is a persistent fear or anxiety about the harm that could lead to loss or separation from attachment figures. The symptoms of separation anxiety disorder often develop in childhood and to be considered for diagnosis the fear and anxiety must last for a period of 4 weeks, and typically last 6 months or longer in adults. Additionally, there

must be significant distress or impairment in social, academic, or other important areas of functioning.[14]

Selective Mutism

Selective mutism is characterized as a failure to speak in social situations where it is normally expected; however, the individual speaks in other situations.[54] With an inability to speak, there is significant interference with achievement in academic settings and normal social communication skills. Selective mutism is not due to a lack of knowledge, comfort, or specific language required for the social situation. Furthermore, selective mutism cannot be better explained by a communication disorder, and cannot occur during autism spectrum disorder, schizophrenia, or another psychotic disorder.[14]

Specific Phobia

A Specific Phobia is characterized as an excessive fear or worry that occurs with exposure to one object or situation. The response is typically out of proportion to a normal response or the actual danger posed. Specific objects or situations that are normally feared are animals, heights, enclosed spaces, blood, needles or injuries.[54] To be considered for diagnosis an individual actively avoids the object or situation or endures with intense fear and anxiety. There is often significant distress and impairment in personal, social, educational, and occupational settings. The signs and symptoms persistently occur over several months with a 6-month minimum.[14,54]

Social Anxiety Disorder

Social Anxiety Disorder is characterized as an individual's abnormal response in an array of social situations including but not limited to: carrying on a conversation, eating in front of others, and public speaking.[55] The social interaction will almost always illicit

fear or anxiety, which is out of proportion to the actual threat posed. Individuals may fear he/she will act in a way that shows anxiety symptoms and will be negatively evaluated. Social Anxiety Disorder typically causes significant impairment in social, interpersonal, and professional settings, and the avoidance behaviors are associated with distress, impaired relationships, and decreased academic performance.[55,56] The core features of SAD include persistent social avoidance and social isolation lasting 6 months or more.[14]

Panic Disorder

Panic Disorder is defined as recurrent, abrupt, unexpected transient episodes of fear, and physical symptoms. At least 1 panic attack must be followed by at least 1 month of persistent concern for having more attacks worry about panic attack consequences or avoidance behaviors.[54,57] Panic Disorder must not be from medication side effects, substance abuse, or other medical conditions and must not be better explained by another disorder.[14] For example, an individual having a panic attack during a social encounter where social anxiety disorder would be a better explanation. Common signs and symptoms that accompany PD include: palpitations, pounding heart or accelerated heart rate, sweating, trembling or shaking, sensations of shortness of breath or smothering, feeling of choking, chest pain or discomfort, nausea or abdominal distress, feeling dizzy, lightheaded or faint, chills or heat sensations, paresthesia, fear of losing control or the fear of dying.[57]

Agoraphobia

Agoraphobia is defined as marked fear or anxiety of public spaces, where an escape might be difficult, or help might not be readily available. These specific situations include use of public transportation, being in open spaces, being in enclosed places, standing in line or being in a crowd, and being outside of the home alone.[14,54,57] The individual is

continuously anxious or fearful about these sensations, and the actual or perceived fear of public spaces are out of proportion to the normal response. These situations are typically actively avoided or endured with significant anxiety and fear. In avoiding specific situations, avoidance behaviors are associated with significant distress in social, work, or other important areas of functioning. Usually, the symptoms of Agoraphobia are persistent for an extended amount of time and can last over 6 months.[14,54,57]

Generalized Anxiety Disorder

Generalized Anxiety Disorder is characterized by a chronic, persistent worry that is not restricted to any particular circumstance, situation, or exposure.[54,58] An essential, main feature of GAD is excessive worry that is difficult to control and may impair function in various environments (e.g., school, work). [42] To be considered for diagnosis, symptoms must persist for a minimum of 6 months more days than not, [42] and cannot be due to another medical condition or be from a substance or medication.[54] Common symptoms that accompany GAD include: muscle tension, sympathetic overactivity (nausea, gastrointestinal distress), nervousness, irritability, difficulty concentrating and sleep disturbances.[54] Symptoms must be severe enough to cause significant distress about experiencing persistent anxiety symptoms or result in significant impairment in important areas of functioning (e.g., family, social, personal, educational, occupational).

Measurement of Anxiety Disorders

To assist in the assessment, semi-structured and structured interviews and self-report measures can be used in addition to the DSM-5 guidelines, and clinical judgment. Commonly in research, semi-structured and structured interviews, and self-report measures are used to provide an estimate on prevalence of symptoms for the desired sample.

Research on anxious symptomology prevalence in college students typically include the following self-report measures: Generalized Anxiety Disorder-7 (GAD-7),[59] Beck Anxiety Inventory (BAI),[60] DASS,[18] State-Trait Anxiety Inventory (STAI),[53] and the Zung Self-Rating Anxiety Scale.[61] The number of items for the self-report measures ranges from 7 to 42. The DASS includes three subscales of 7 items each, where anxiety has been assessed within the 7 items. Self-report measures are often used for screening of symptoms and may indicate when an individual is experiencing symptoms that place them at risk.

Measurement of Anxious Symptoms in Student-Athlete Research

Instruments used to examine anxiety in research include the BAI, Sport Anxiety Scale, Cognitive Appraisal Scale in Sport Competition- Threat Perception, COPE Inventory, Brief COPE Inventory, Competitive State Anxiety Inventory, Sport Competition Anxiety Test and STAI.[62] Most commonly the BAI and STAI have been used in the collegiate student-athlete population.[23,24,63] The BAI is a validated 21-item instrument that measures the severity of self-reported anxiety symptoms. A higher score indicates greater severity of anxiety symptoms being experienced. The STAI is a validated screening instrument that assesses state and trait anxiety. There are 20 items to assess trait anxiety and 20 items for state anxiety. Reliability for this instrument ranges from .65 to .75,[53] with test-retest reliability ranging from .69 to .89.[64]

Etiology of Anxiety Disorders

The etiology of anxiety disorders can be assessed in four areas: biological, psychological, social, and sociocultural. The biological dimension focuses on physiological responses and the influence on genetics. The fear circuitry in the brain and its effect on genetics is an important feature of the etiology of anxiety disorders. The

amygdala is the key structure for forming and storing memories associated with emotional events. When a possible threat is encountered, the stimulus activates the amygdala, further triggering the HPA axis to prepare for “fight or flight” reaction. The reaction associated with these triggers may overpower rational thinking, and the survival reactions take over.[30] Once the HPA axis is engaged, it requires higher-level processing to stop the response. In anxiety disorders, this response is heightened and is harder to "turn off." Heightened responses can cause a higher frequency of anxiety symptoms. The role of genetics in developing anxiety disorders is largely determined on interaction with environmental influences.[30] It is suggested that the same short serotonin allele (5- HTTLPR) involved with depression is also a factor in anxiety. The actual expression of the allele depends on the interaction with the environment.[30] A decreased level of serotonin increases fears and anxiety-related behaviors.

The psychological dimension of anxiety largely focuses on the individual’s psychological characteristics and its association with genetic or environmental predispositions.[30] Individuals that practice negative appraisal are at a higher risk for developing an anxiety disorder. A negative appraisal is defined as interpreting events as threatening. There is a lower threshold for uncertainty, and therefore, a lack of sense of control may play a factor in development.

Social and socio-cultural dimensions can be combined with anxiety disorders. The common daily environmental stressors include: financial stress, living in poverty or unsafe environments, traumatic events, school shootings or natural disasters, and adverse working conditions.[30] While both genders are at risk for experiencing the common daily stressors, females are at a higher risk to develop anxiety. It is thought that a lack of power, status,

poverty, stressors, and lack of respect can affect emotional responses. Culture also plays an important role in anxiety disorders.[14,30] Those individuals who are exposed to discrimination and prejudice can be at risk for anxiety disorders. Furthermore, culture can influence how anxiety is expressed. In Western cultures, anxiety is known as the fear of embarrassing oneself, whereas, in Asian cultures, it is a worry of being offensive to others.[30] In summary, the etiology of anxiety disorders may be cumulative and include various components from each dimension. It is vital to recognize the different components and understand how each dimension may impact an individual for prevention and intervention purposes.

Anxiety Disorder Risk factors

Development of anxiety disorders can be due to many risk factors. Established risk factors in the general adult population for anxiety disorder onset include age, female gender,[58,65,66] limited economic resources,[58,66] ethnicity,[66,67] marital status, smoking and alcohol problems,[58,66] stressful life events in childhood or adulthood, [58,65, 66] traumatic experiences,[67] history of parental mental disorders, mental health disorders in the affected individual,[66] low self-esteem.[67] Similarly in the college student population, Cheng et al.,[68] has identified risk factors for anxiety disorders in addition to those for the adult population to be academic anxiety, low social support, internet addiction, suicidal ideation, and poor sleep quality. While there are many established risk factors for anxiety disorders, the risk factors listed are not specific to one mental health disorder, rather numerous.

In addition to the generic risk factors for anxiety disorders, student-athletes may also experience more risk factors in sport. The research on anxiety risk factors in collegiate student-athletes is limited. A current focus of research is using anxiety as a risk factor for

injury or performance failure.[24] In a cohort study of NCAA Division I athletes, preseason anxiety was measured at enrollment and injuries were followed through the season. Results indicated that athletes who reported preseason anxiety had a significantly higher injury rate than those without anxiety symptoms.[24] Preventative screening, early identification of anxiety symptoms, and intervention in student-athletes may help reduce injury rates and reduce the risk for other mental health disorders to develop. Another focus in the research is examining anxiety in the context of performance. The systematic review by Rice et al.,[69] identified four studies that focused on anxiety symptoms and performance outcomes. Overall, an athlete's focus on performance increased anxiety and was found to be related to negative patterns of perfectionism.[69] Although the research is limited to the risk factors of anxiety in student-athletes, it is suggested that performance and injury can be related to anxious symptoms. The risk factors of anxiety should be examined further to assist in the development of prevention programs. Early identification through screening programs can be beneficial in reducing injury rate and psychological distress and may facilitate better performance.

In addition to performance and injury as a risk factor for anxiety, there are also risk factors associated with being a student-athlete and adjusting to campus life. Hwang and Choi[70] examined pre-existing NCAA data from 2010 to explore relationships among demographics, personal characteristics, and social characteristics. Results showed academic anxiety, physical well-being, and social contexts to be significant factors of stress for student-athletes. Academic anxiety was the most important factor for perceived stress.[70] Just as there are generic risk factors for anxiety disorders in the general population, the risk factors for student-athletes are general and non-specific to student-athletes. Identification

of risk factors for student-athletes would not only benefit the development of prevention programs but would also inform those working with student-athletes of what to monitor.

Prevalence of Anxiety Disorders

A National Comorbidity Survey Replication in 2001-2003 reported an estimated prevalence of Specific Phobia, SAD, PD, Agoraphobia, and GAD. These prevalence rates were based on diagnostic interview criteria through a national survey conducted between February 2001 and April 2003, with a response rate of 79%.[71] The estimated prevalence of US adults in the past year for specific phobia is 10.1%, with higher rates for females (12.2%) than for males (5.8%). Regarding SAD, the estimated prevalence of US adults in the past year is 8.0% with higher rates found for females (8.0%) than for males (6.1%). The 12-month prevalence rates are much lower for PD, Agoraphobia, and GAD, and consistently higher in females than males. Specifically, the total prevalence for PD in US adults is 2.7%, 3.8% in females and 1.6% in males. Agoraphobia has the lowest 12-month prevalence of the anxiety disorders with 1.7%.[71] Lastly, the 12-month prevalence of GAD in US adults in the past year is 2.9%, with females at 3.4% and males at 1.9%.

The overall prevalence for the various anxiety disorders in student-athletes is largely unknown. Previous literature has minimally studied SAD and PD in student-athletes, with the prevalence rate at 14.7% and 4.5% respectively in a sample of Australian athletes aged 18-25.[72] GAD has also been minimally studied in the student-athlete population. The prevalence rates for GAD in a student-athlete population ranged from 6.0%[73], with a confirmed clinician diagnosis of 28.8%[24] using self-report measures. Consistent with the general population, females report higher symptom ratings than males.

The prevalence rates for a specific phobia and agoraphobia are unknown in a student-athlete population.[35]

Overall, much of student-athlete research focuses on the prevalence of anxiety symptoms. Specifically using the STAI, Yang, et al.,[74] indicated 1 in 3 student-athletes presented with anxious symptoms at enrollment of the study and reported lower scores than the general population for anxiety. While this study did not demonstrate a higher prevalence in anxiety symptoms when compared to the general population, it does illustrate approximately 33% of the student-athletes presented with anxious symptoms. Additionally, another study estimated 21.7% student-athletes reporting symptoms of anxiety and of those, 49% reported symptoms before the season began. Males reporting preseason anxiety were 3 times more likely to become injured compared to those without preseason anxiety, and females were two times more likely.[24] It is apparent that symptoms of anxiety are a possible predictor of injuries throughout a season in those reporting anxious symptoms. With appropriate recognition and identification of anxiety symptoms in student-athletes, it is possible interventions can work to decrease symptoms over time.

Suicide

Suicide is defined as a death caused by self-directed injurious behavior with intent to die as a result.[75] Mental health disorders are major risk factors for suicide. Suicidal behaviors are defined as suicidal ideation, suicidal plan, and suicidal attempt. Suicidal ideation is the action of thinking about, considering, or planning suicide. Suicidal plan refers to the formation of a specific plan to end one's life, and suicide attempt relates to engagement in suicidal behaviors with an intent to die.[75] Suicidal behavior and ideation

begin with an individual's initial suicidal thoughts. Individuals will develop a plan, and a smaller number of individuals attempt suicide.

According to the Centers for Disease Control and Prevention Leading Causes Death Reports, suicide was the tenth leading cause of death in the United States and second leading cause of death among individuals aged 10-34.[76,77] Furthermore, data from the 2016 National Survey on Drug Use and Health[76] states 4.0% of adults 18 and older had suicidal thoughts, with 8.8% of individuals aged 18-25 presenting with the highest percentage of adults having severe thoughts of suicide. Nine point eight million adults aged 18 or older reported having serious thoughts of killing themselves, and 1.3 million adults attempted suicide during the past year, with 1.0 million reported making suicide plans.[76] Although females are at a higher risk for most mental health disorders (i.e., depression, anxiety), males are at a higher risk of completing suicide.[76] Females are more likely to attempt suicide; however, males are more likely to succeed. The rates of suicide for race and ethnic groups in 2016 were highest for males (32.8 per 100,000) and females (10.2 per 100,000) in the American Indian/Alaska Native group, followed by males (26.5 per 100,000) and females (7.9 per 100,000) in white/non-Hispanic group.[76]

Measurement of Suicide and Suicidal Ideation

The screening instruments used for suicide vary and are inconsistently used across the research. The most common method used in research to determine suicidal tendencies stems from the National College Health Assessment (NCHA) survey. The NCHA is a nationally recognized survey that provides data on the health habits, perceptions, and behaviors of college students.[78] In the NCHA survey, a mental health question asks if the individual has ever seriously considered suicide or attempted suicide in addition to

numerous other questions. Possible responses include: No never, no not in the last 12 months, yes in the last two weeks, yes in the last 30 days, and yes in the last 12 months. This question can be easily adapted into current PPE screenings, and any response indicative of suicidal tendencies would initiate a conversation with a mental health professional.

Currently, the NCAA does not provide or recommend screenings for suicidal ideation for student-athletes; however, it does provide screenings for depression, anxiety, insomnia, drug, and alcohol use. Screenings of suicidal risk factors and mental health disorders like depression, anxiety, and substance abuse can help identify individuals who may need additional mental health care. Athletic trainers and any other medical professionals handling the screening of student-athletes need to be aware of the risk factors of suicide and be confident in making a referral.

Suicide Risk factors

The literature identifies numerous risk factors for suicide that coincide with both depressive and anxiety disorders. One of the most well-known risk factors for suicide is MDD.[14,30,79,80] Depressive signs and symptoms of hopelessness, guilt, sadness, fatigue, insomnia, or excessive sleep can all affect suicidal ideation. The symptoms of hopelessness, fatigue, and insomnia have been studied extensively in the college student population and are associated with suicidal ideation.[79-81] In a recent publication, suicide risk factors were identified to predict suicidal ideation in college students.[79] Depression, current suicidal ideation, social phobia, alcohol problems, low self-esteem, and the number of close relationships were identified as risk factors for suicidal ideation in college students.[79] Specifically, as depressive symptoms, sleep problems, age, and the number of

alcohol problems increased, a positive correlation with suicidal behaviors was noted.[80,81] Supporting literature also states that sleep disturbances,[82] fatigue,[80] hopelessness,[81] alcohol problems,[79,81] gender-sex- orientation,[75] and low levels of social support[81] are risk factors for suicide. Sleep problems are more common in college-aged individuals and can be linked to suicide.[82] Using a large sample of college-aged students (n=1700), poor sleep was associated with increased suicidal behaviors with and without controlling for depression. Furthermore, short sleep duration, frequent nightmares, feeling too cold while sleeping, and increased sleep medication used is also associated with increased suicidal behaviors.

Anxiety disorders are also risk factors for suicide. A recent systematic review indicated anxiety and anxiety disorders are statistically significant for suicidal ideation and attempts, but not deaths. The relationships between anxiety, anxiety disorders, and suicide were all weak, and provided small odds ratios to support as a risk factor.[83] While anxiety symptoms and disorders can be debilitating, the link between anxiety disorders and suicide is weak. Anxiety symptoms and disorders alone may not be a strong risk factor for suicide, but a combination of risk factors may increase the risk of suicide.

Mental health disorders cause psychological distress and dysfunction in everyday life. While the impacts of mental health disorders are individualized, there is a risk for the inability to continue through life. The rates of suicide in undergraduate college student-athletes is relatively low compared to other undergraduate college students.[84] It has been suggested that sport is associated with higher social support and increased self-esteem with achieving success.[85] Despite potential protective factors, student-athletes are at a higher risk for suicide with anabolic steroid use, physical illness or injuries, drug abuse, and alcoholism, previous or current psychiatric problems, childhood trauma, bullying and

sexual abuse, agitation, impulsivity, interpersonal conflict, anxiety, sleep disturbance, aggression, hopelessness, prior suicide attempts and retirement from sport.[35,84-87] It is well-known that depression is a significant risk factor for suicide; however, there is a need for more investigation into suicide in student-athletes.

In the general population, the prevalence of mental health disorders is characteristically higher in females; yet, males have a higher prevalence in completing suicide. This is largely because the mode of taking one's life, where men use more lethal methods (e.g., gunshot) and women tend to use an attempt as a cry for help. Understanding the association of depression, anxiety, and suicide in student-athletes is imperative for prevention programs and interventions.

Prevalence of Suicide and Suicidal Ideation

According to the Centers for Disease Control and Prevention Leading Causes Death Reports suicide was the tenth leading cause of death in the United States and second leading cause of death among individuals aged 10-34.[76,77] Furthermore, data from the 2016 National Survey on Drug Use and Health[76] states 4.0% of adults 18 and older had suicidal thoughts, with 8.8% of individuals aged 18-25 presenting with the highest percentage of adults having severe thoughts of suicide. Nine point eight million adults aged 18 or older reported having serious thoughts of killing themselves, and 1.3 million adults attempted suicide during the past year, with 1.0 million reported making suicide plans.[76] Although females are at a higher risk for most mental health disorders (i.e., depression, anxiety), males are at a higher risk of completing suicide.[76] Females are more likely to attempt suicide; however, males are more likely to use more lethal methods. The rates of suicide for race and ethnic groups in 2016 were highest for males (32.8 per 100,000) and females

(10.2 per 100,000) in the American Indian/Alaska Native group, followed by males (26.5 per 100,000) and females (7.9 per 100,000) in white/non-Hispanic group.[76]

Research in suicide prevalence in collegiate student-athletes is limited due to the nature of suicide. Research in suicide prevalence relies on the retrospective review of student-athlete deaths and examination of suicidal ideation. Rao et al.,[84] recently performed a retrospective review of student-athlete deaths from the years 2003-2012 to determine the rate of suicide in NCAA Divisions I, II, and III. Results indicated that the overall mortality rate was 12.6/100,000 student-athletes per year, with 35 confirmed cases of suicide and six suspected. Suicide made up 7.3% of all-cause mortality with a rate of 0.93/100,000 student-athletes per year. Males made up 82.9% (29/35) of suicide cases with football athletes representing the highest number of cases in sport.[84] This retrospective review not only provides the suicide rate in collegiate-student athletes but also provides football as a common sport these individuals participated in. Further investigation in why football is more common over the other sports may provide insight on the mental health disorders present in a male dominant sport.

In another retrospective study, authors examined participation in sport and suicidal behavior from the 1995 National College Health Risk Behavior Survey. A total of 10% percent of students reported prior suicidal ideation, and 1.5% reported a prior attempt.[88] Furthermore, 10.6% of those not participating in sport reported seriously considering suicide and 6.9% of those participating in one or more sports reported seriously considering suicide.[88] Therefore, the data suggested that those participating in sports were less likely to have experienced suicidal ideation and make plans for suicide, but not for suicide attempts.[88] Collegiate student-athletes have lower rates of suicide than individuals of the

college age, and it can be suggested that participation in a sport(s) may be a protective factor for depression and suicide.

Depression and Anxiety Prevention

The primary goal of prevention programs for mental health disorders is to promote mental health in a way to improve wellbeing and prevent adjustment difficulties.[89] Prevention programs can either be universal, indicated, or selective. To be considered as a universal prevention program, the intended individuals of reach do not have any pre-existing mental health problems of interest, whereas in an indicative prevention program the interventions are aimed to those showing signs and symptoms of a mental health problem (i.e., depression, anxiety). Selective prevention programs are designed to target a population determined to be at risk for mental health problems. Within prevention programs, common strategies implemented include psychoeducation and skills training through Cognitive Behavioral Therapy, relaxation, meditation, and mindfulness. There are systematic reviews that identified the types of programs most effective as a prevention program and provided suggestions for future research.[89,90]

In the higher education setting, universal mental health prevention programs have been effective in improving social and emotional skills, enhancing self-perception, reducing the distress associated with depression, anxiety, and stress. Skill-orientated intervention with supervised practice was more effective than skill-orientated and psychoeducational interventions and was more likely to have remaining effects.[89,90] Of the programs evaluated, mindfulness interventions with supervised skills practice were significantly more effective than the other intervention strategies (e.g., psychoeducation, cognitive behavioral, relaxation, mindfulness, and meditation.[89] When examining mental

health specific outcomes (e.g., improve self-esteem, reduce general distress) the order of effectiveness was relaxation, cognitive-behavioral, mindfulness, meditation, and psychoeducation.[90] Overall psychoeducational programs had been found to be less effective than face to face or group skill oriented interventions when the intent is to improve mental health promotion and overall well-being. To continue to improve mental health and wellbeing in college students, programs are encouraged to include skills practice, where individuals can become comfortable using those skills to handle stressful situations.

Mental health prevention programs in college students have been conducted with various modes of delivery. These modes include individual or group settings either face to face (FTF) or more recently with forms of technology. FTF interventions have been deemed effective in prevention programs; however, the reach of these programs can be limited. Technology-based interventions have been increasing in popularity and have been thought to be as effective in administering preventative mental health programs for various populations as FTF interventions. Specifically, in the college student population, technology-based programs have been effective in reducing symptoms for depression, anxiety, and stress.[91] Technology-based intervention programs can be self-administered and completed at the participant's own pace. In terms of reaching more participants and being more cost-effective, technology-based programs have the potential to be as effective as FTF prevention programs.

Technology-based prevention programs have the potential to be effective in promoting mental health and wellness in collegiate student-athletes. Collegiate student-athletes have limited free time outside of their sport's routine, academics, and social lives. Additionally, there is a stigma associated with seeking help for mental health concerns.

Technology-based prevention programs not only allow the collegiate student-athletes to participate privately but also allow student-athletes to participate at their leisure. Technology-based programs have the potential to reach more student-athletes but also can help reduce general distress, depressive, and anxious symptoms. However, there is limited research on technology-based prevention programs and whether it is an effective means for collegiate student-athletes to use.

Currently, per a systematic review on interventions to increase mental health and wellbeing in athletes in 2017, only 2 interventions were conducted using a form of technology.[5] The interventions used were web-based mental health literacy programs for either 1 session for approximately 10 minutes[92] for 5 weeks[93] with the goal to improve mental health literacy in athletes. Currently, there are no prevention programs specifically designed to improve mental health and wellness outcomes in student-athletes and reduce stress, depressive or anxious symptoms or improve the overall quality of life. Technology-based programs have the potential to be a confidential, time-efficient, and effective means for prevention programs for student-athletes.

Depression and Anxiety Treatment Options

There are various modes of treatment available for depressive and anxiety disorders. The usual course of treatment includes medication, psychotherapy, or a combination of the two.[30] In terms of medicine, common types of medications used to treat depressive and anxiety disorders in both in general population and college students include Antidepressants (e.g., Fluoxetine, Paroxetine, Bupropion), Anti-Anxiety medications or Benzodiazepines (e.g., Clonazepam), Antipsychotics (e.g., Chlorpromazine, Risperidone) and Mood Stabilizers (e.g., Lithium).[94,95] In addition to unknown performance effects and

safety concerns, some medications can cause adverse side effects, including fatigue, tremors, and weight gain.[87,94,95] Limited research is available on medications in student-athletes, further indicating a concern for prescribing.

Treatments using medications are often paired with psychotherapy. Depressive and anxiety disorders can be treated using psychotherapy. Cognitive behavioral therapy, exposure therapy, and mindfulness training treatments are commonly found in psychology research. Cognitive behavioral therapy is an active, time-sensitive and strategic intervention that focuses on the cognitive restructuring of maladaptive thoughts; whereas exposure therapy is defined as regular contact with a feared stimulus or situation to facilitate the reduction in the fear response. Mindfulness training is defined as awareness from paying attention to the present moment in a purposeful non-judgmental manner. Each of these psychotherapies has been well established in the college student population as an effective treatment for reducing depressive and anxious symptoms.[89,90]

Student-athletes have been suggested to be good candidates for Cognitive Behavioral Therapy because of the structure, direction, practice, goal-setting, and self-reliance associated with the foundation of the treatment.[87] However, Cognitive Behavioral Therapy has not been explored in student-athletes. For anxiety, exposure therapy has been used as a critical strategy for reducing anxiety. More research is needed in the application of these psychological treatments in student-athletes,[96] however, a case study was published to discuss potential exposure treatments in athletes with performance anxiety.[97] Exposure treatment for this athlete helped develop new behaviors and decreased anxiety pre-and post-competitions. Gustafsson and colleagues[97] provided a case in which exposure helped an athlete with anxiety and provided a framework for future research in Cognitive

Behavioral Therapy and exposure therapy for athletes. Case studies can solely provide a potential framework of what was successful, but there are no statistics to demonstrate the effectiveness and therefore need to be used with extreme caution.

Mindfulness training has been minimally examined in student-athletes in combination with a yoga program. Authors conducted an intervention with NCAA Division I student-athletes to explore utility, feasibility, and efficacy of a mindfulness intervention for student-athletes. This 56-week program was administered to males on one varsity sport. There were 8, 90-minute sessions of mindfulness-based sessions and 60-minute yoga sessions. The results indicated less perceived stress and greater mindfulness. Authors suggest the results offer preliminary support for brief psychological interventions with mind-body exercises for student-athletes.[98] These preliminary studies on exposure therapy and mindfulness training in student-athletes demonstrate a reduction in depressive and anxious symptoms and overall improved wellness. Due to limited research in this area, the potential for stress reduction and improvement in overall wellbeing is unknown in the student-athlete population. However, it seems the psychotherapy options of exposure therapy and mindfulness-based training have the potential to be beneficial for student-athletes to practice when experiencing high levels of stress or anxiety about school, their sport, or everyday life.

Depression and Anxiety Interventions

Intervention programs are designed to improve mental health outcomes in participants experiencing symptoms or those who have been diagnosed with a mental health disorder. Specifically, in the college student population, research has focused on improving mental health outcomes in those experiencing symptoms. Mental health

interventions can be carried out through individual or group FTF sessions, technology-based sessions, or in a combination format. The intervention types cognitive-behavioral, mindfulness, meditation, and psychoeducation have been used to improve symptoms of depression, stress, anxiety, the quality of sleep, and any psychological distress.[99,100] In a systematic review, it was noted that all interventions examined, demonstrated effectiveness over control groups in reducing symptoms of all mental health outcomes, including depression and anxious symptoms.[99] All interventions also demonstrated effects that lasted up to 12 months after the intervention and the FTF group sessions provided the best outcomes.[99] Designing an intervention with face to face sessions seems to be appropriate for longer lasting effects.

Technology-based interventions for mental health outcomes have also been conducted and evaluated for the college student population. Technology-based interventions can be cost-effective, reach more students, and provide participants with an effective intervention at their own pace. Earlier research indicated internet-delivered treatments for individuals diagnosed with mood and anxiety disorders would be effective in addition to existing services, and that more research was needed to conclude inferiority, the long-term effects, adverse effects, and efficacy when administered alone.[101] More recently, in individuals diagnosed with a depressive disorder, internet, and mobile interventions were more effective compared to attentive and waitlist controls with a significant decrease in depression severity.[102] Technology-based interventions seem to be effective in reducing depressive and anxious symptoms in individuals with a diagnosed condition. It is suggested that technology-based interventions would also be effective in college students experiencing symptoms of depression and anxiety.

Many technology-based interventions have been conducted to improve mental health outcomes (e.g., depressive and anxious symptoms, sleep quality)[103-107] and promote healthy transition in college.[108] The interventions were administered via electronic mail, text messaging, online websites, or mobile applications. The effects of the technology-based interventions demonstrated improvements in depressive and anxious symptoms, increased sleep quality, decreased perceived stress, and higher levels of life satisfaction. Programs were designed to last 6 to 8 weeks, with one program lasting only 10 days. Technology-based interventions have shown efficacy in improving mental health outcomes for college students. The most efficient mode of deliverance has not yet been established; however, an intervention conducted with the use of a mobile application has shown to be effective in 10 days of use. The authors Flett, Hayne, Riordan, and Connor,[106] examined the use of 2 smart-phone based mindfulness meditation apps to improve mental health outcomes. The intervention was designed to last 10 days, where participants would engage in the designated app for 10 minutes a day. Using brief, mobile mindfulness practice has shown improvements in depressive symptoms, college adjustment and resilience.[106] Technology-based interventions have the possibility to be extended to student-athletes with its ease, limited time commitment, and mental health outcome effects. However, this has not been investigated in this population.

Currently, student-athlete interventions for mental health are primarily psychoeducational with a focus on increasing mental health awareness and well-being in student-athletes.[5] With an increase in mental health research and an increasing prevalence rate of depressive and anxious symptoms in collegiate student-athletes, the NCAA is encouraging mental health and wellness programs in athletic institutions. Furthermore,

researchers have indicated a need for prevention programs and interventions for student-athletes to reduce depressive and anxious symptoms.

Recently, Goodman and authors[98] aimed to reduce stress, depression, and anxiety symptoms using a mindfulness and yoga pilot intervention in student-athletes. The intervention was designed to be a 5-week program with 8, 90-minute sessions followed by 60-minute yoga sessions. As a result, the program demonstrated lower levels of perceived stress, higher tolerance of negative experiences, and higher levels of mindfulness indicating a mindfulness-based intervention might be feasible for student-athletes. Due to limitations with this study, it is unknown whether this program would translate to student-athletes of individualized sports and would be time efficient for student-athletes in general. While mindfulness-based programs have the potential to be an effective intervention for student-athletes, more research is needed to determine its effectiveness.

Depression and Anxiety Return to Play

Mental health disorders have been found to slow the return to play process in student-athletes. Anxiety has been extensively examined with the concept of the fear of returning to sport after an injury demonstrating implications for rehabilitation of athletic injuries. In a clinical review of the fear of re-injury in athletes, it was suggested clinicians should use self-report measures to help determine the readiness for return to play. Also, psychological interventions (e.g., exposure therapy, imagery) could be intertwined into the rehabilitation process to facilitate a successful return to play.[109] To date, research has not examined interventions designed to supplement return to play rehabilitation programs, and it is unknown how mental health intervention programs will benefit student-athletes and their recovery and return to play.

Furthermore, there are differences in the patterns of psychological disturbances after orthopedic and concussive injuries. Guo et al.,[110] examined both depressive and anxious symptoms at baseline, injury, and with follow up surveys until return to play. The concussion group scored higher on depressive symptoms than the orthopedic injury group one month after injury. Both groups reported the same score of depressive symptoms at baseline and one week after injury; therefore, demonstrating the difference in patterns of psychological differences occurred later. The results of this cohort study indicate that psychological disturbances are different between orthopedic and concussive injuries. The timeline of anxious and depressive symptoms occurs at different time points in the return to play process. There is a need to identify factors that contribute to these differences in psychological patterns after injury.

Injury poses a stressful situation for student-athletes to overcome. As previously mentioned, injuries can cause different patterns of psychological response to injury. Research encourages clinicians to utilize self-report screening tools to asses for psychological disturbances through the rehabilitation process. Additionally, the assessments should be performed at various time points in the rehabilitation process to account for the fluctuations of symptoms. Development of a prevention program for all student-athletes may help mitigate psychological signs and symptoms after injury. With a lack of research in this area, it is unknown how prevention programs for student-athletes will help with mental health, performance, and recovery outcomes.

Psychophysiology and Biofeedback

Psychophysiology is defined as an interaction of mental, emotional, and physiological functions (e.g., muscle function, brain activity, skin temperature,

cardiovascular activity, respiration).[111] Physiological functions are measured with various biofeedback modalities, for example, muscle contraction and relaxation can be measured with Electromyography (EMG); brain activity is measured with Electroencephalography (EEG); cardiovascular activity can be measured via heart rate, heart rhythm, and blood pressure; and respiration can be assessed by the rate of breathing and the depth of each breath.[6] With the use of biofeedback modalities, individuals can visualize their measurements in real time and gain control of their physiological functions.[6]

Through the process of biofeedback, individuals increase awareness of their thoughts and emotions.[112] The overall goal of biofeedback is to reduce sympathetic arousal of the autonomic nervous system. Sympathetic arousal includes heart rate, skin surface temperature, and heart-rate variability (HRV). With time and practice, individuals can self-regulate their thoughts, feelings, and behaviors related to their stressors. Self-regulation is a common practice used in conjunction with biofeedback. Self-regulation is defined as a process where individuals learn to influence body and mind actively, to decide to engage emotionally or mentally and shift into the most needed area.[113] Learned self-regulation is a skill that individuals learn to recognize and visualize their psychophysiological response to emotions and incorporate strategies to control the effects. Through learned self-regulation, individuals regain control in thoughts and feelings of frustration, anger, anxiety, overwhelmed, hopelessness, and depression.[114]

Inner Balance

The HeartMath Institute has extended research on the effect of heart activity on brain function by specifically developing HRV biofeedback modalities such as EmWave™ and Inner Balance™. HRV is the fluctuation in the length of the heartbeat intervals, which

changes in response to physiological and environmental stimuli.[115] HRV can be assessed using an electrocardiogram. HeartMath™ Institute has validated assessing HRV waveforms to detect physiological and emotional responses in the ANS. A healthy HRV indicates resilience and behavioral flexibility and the ability to adapt to stress. Low HRV indicates possible disease and disorder.[7,116] To examine HRV, the EmWave™ and Inner Balance™ technologies allow individuals to see their HRV and coherence in real-time. Further, using pulse information, the technologies enable individuals to see heart rate continually. The goal of biofeedback and HRV assessment with Inner Balance™ is to train individuals to recognize their heart rate waveforms and implement training (e.g., Heart-Focused Breathing Technique™, Quick Coherence Technique™, Heart Lock-In Technique™, Coherent Communication Technique™, Freeze Frame Technique™, Attitude Breathing Technique™) into their daily life.

Coherence

Increased order and harmony in psychological and physiological processes are defined as psychophysiological coherence. A state of psychophysiological coherence is also known as the optimal state of function for individuals.[7,116] When coherence is achieved and activated, the physiological systems function more efficiently, and individuals experience mental clarity and improved cognitive function.[7,116] Physiological coherence is characterized as a heart rhythm of elevated amplitude in low-frequency HRV of around 0.1Hz, that typically occurs at about 6 breaths per minute. A sine, wave-like pattern in HRV demonstrates heart rhythm coherence and a shift in the autonomic nervous system toward increased parasympathetic activity. There is increased synchronization of bodily symptoms controlled by the heart.

Coherence is not a state of relaxation, rather positive emotional state of optimal alertness induced via attention to breathing into the heart area and creating a positive emotion from the body. During relaxation, there is a reduction in HRV and increased parasympathetic activity, whereas coherence includes a natural resonant frequency with the heart-brain interaction. There is not a change with HRV in coherence, rather a change in the heart rhythm pattern. Within individuals that are stressed, frustrated, or anxious, the heart rhythm looks irregular and erratic, whereas those in psychophysiological coherence display a smooth, harmonious wave. The Inner Balance™ technology measures and quantifies heart rhythm coherence and displays it in real-time.[7,116]

HeartMath Self-Regulation Techniques

HeartMath™ self-regulation techniques were designed to enhance psychological, physiological and emotional information processing. The techniques are not designed to bring up old, ineffective patterns for problem solving, instead individuals may use the techniques to learn new patterns and resolve problems more effectively in their daily lives.[7,116] All techniques begin with a breathing rhythm to help disengage from negative thoughts and bring the individual to a more coherent heart pattern. All techniques also include an intentional shift to a more positive emotional state. [7,116]

Heart-Focused Breathing Technique

Typically, the Heart-Focused Breathing Technique™ (HFB) is the one of the first self-regulation skills taught. Individuals are instructed to neutralize their feelings and emotions and take out the "drama" of everyday life, and by doing so taking responsibility for their emotions.[7,116] By neutralizing their emotions, individuals are able to reduce negativity and instead be more effective in considering consequences and options for

problem solving. HFB has been used with managing anger, anxiety disorders, acute and chronic pain, and post-traumatic distress syndrome (PTSD).[7,116] The HFB technique is completed through a quick and easy step. Individuals are instructed to focus their attention around the heart. Next, to imagine their breath is flowing in and out of their heart or chest area, breathing slower and deeper than usual. Using a suggestion of 5 second intervals for breathing and focusing on the area around the heart, an individual is able to slowly regulate their heart rate and breathing to reduce stress.[7,116]

Quick Coherence Technique

To achieve coherence beyond simple breathing tasks, the HeartMath Institute have developed self-regulation techniques. One quick technique commonly used is called the Quick Coherence Technique™ (QCT). Learning this skill allows individuals to build self-regulatory skills, create positive situations, and learn how to respond to a negative circumstance.[7,116] This technique is completed through 3 easy steps. First, individuals focus their attention on the area of the heart. Next, the individual focuses on their breathing, inhaling for 5 seconds, and exhaling for 5 seconds, finding a comfortable rhythm. While the individual is breathing, an attempt should be made to visualize their breathing on the monitor or screen. Third, make a sincere attempt to experience a regenerative feeling, such as appreciation or care for someone or something in life. The QCT steps all together take less than a minute to complete and are designed to be transferable into stressful life situations.[7,116]

Coherence Communication Technique

The Coherence Communication Technique™ (CC) is used to create better understanding and connection between listeners and speakers.[7,116] CC is effective to learn

especially in health care fields, but also in the sport setting. Effective communication between teammates, coaches, and medical professionals helps individuals feel heard, be more open, and possibly disclose more information. This technique is completed in three easy steps: 1) shifting into a heart-coherent state before communicating to share and receive information, 2) listen without prejudging or pulling in drama before the communication is complete and speak genuinely, and 3) confirm the essence of what you heard to insure mutual understanding.[7,116] This technique is not directly used to reduce stress and anxiety; however, it can be used to help individuals open up and improve their communication to negate negative perceptions from conversations with others.

Heart Lock-In Technique

The Heart Lock-In Technique™ (HLI) is an emotional restructuring tool often used in conjunction with the QCT. The HLI is designed to refocus emotions from negative to positive and building the capacity to sustain the positive emotions for longer amounts of time.[7,116] Individuals develop stamina, more composure and improve in their decision-making skills through the shift into coherence. Through practice, the shift into coherence becomes readily available for individuals, providing a more effective means to addressing anxiety and stressful situations. HLI is useful for changing behaviors, developing motivation and energy to bring about a change in their lives. The technique has been used for depression, loss, grief or PTSD.[7,116] HLI can be completed in three, easy steps. These steps include: 1) focusing attention in the area of the heart and imagining their breath flowing in and out of the heart area, breathing slower and deeper than normal, 2) activating and sustaining a regenerative feeling such as appreciation, care, or compassion, 3) radiate the renewing feeling from step 2 to yourself and others. It is suggested to remind the

individuals that with any wandering thoughts, to refocus their attention on the area of the heart and reconnect with the regenerative feelings. [7,116]

Freeze Frame

Another emotional restructuring technique developed by HeartMath™ and often used in conjunction with other self-regulation skills and biofeedback is the Freeze Frame Technique™ (FF). There are 5 steps in the FF Technique. First, individuals are to acknowledge the problem or issue and attitudes associated with it. Step 2 is to focus attention to the heart, inhaling for five seconds and exhaling for 5 seconds, finding a comfortable rhythm. The third is to make a sincere attempt to experience a regenerative feeling, such as appreciation or care for someone or something in your life. Fourth, the individual is to ask themselves what would be a more efficient or effective attitude, action, or solution. Finally, the individual quietly observes any subtle changes in perceptions, attitudes, or feelings and commit to sustaining beneficial attitude shifts and acting on new insights.[7,116]

Attitude Breathing

Attitude Breathing Technique™ (AB) is one of the most commonly used techniques from HeartMath™. The technique combines elements of emotional refocusing and restructuring to undercover draining, nonproductive attitudes and replaces them with new attitudes.[7,116] The AB helps individuals replace draining, negative attitudes with healthier, positive attitudes to become more productive and assertive. The first step for the AB technique is to have the individual recognize a feeling or attitude that they want to change and then identify a replacement attitude. An example of this step would be recognizing a feeling of anxious and replacing it with breathing calm. When instructing the AB

technique, a list of unwanted feelings or attitudes and the replacement feelings or attitudes are provided to the individuals as an example to follow. The next step has the individual focusing their attention to their heart and chest area, imagining their breath flowing in and out of their heart, breathing slower and deeper than usual. The third step encourages the individual to breathe the feeling of the new attitude slowly and casually through the heart area.[7,116] This technique may take time to replace negative attitudes, but with practice and breathing with the new attitude will come easier to the individuals.

EmWave Research

EmWave™ technology has been previously used and researched in numerous populations, including but not limited to college nursing students,[8] college students [9,10] for stress and anxiety. In the study with college nursing students, Ratansiripong et al.,[8] conducted a 5-week intervention, with 2 training sessions to instruct participants on the device and techniques on slowing breathing and enhancing positive emotions. After 5 weeks of using the biofeedback device and techniques learned in the 2 sessions, results indicated that stress levels remained consistent in the biofeedback group, and anxiety decreased.[8]

Ratansiripong et al.,[9] recruited college students from the university counseling center and randomly assigned to a treatment or placebo group. The placebo group received four sessions of counseling in four weeks, and the treatment group received four sessions of counseling and four sessions of biofeedback training in four weeks. The results of this study indicated participants who received both counseling sessions and biofeedback training sessions significantly reduced their anxiety symptoms.[9] These studies both found reductions in stress and anxiety, and further suggests portable biofeedback devices are

beneficial for college students in reducing stress and anxiety. HeartMath™ technology has also been used in a college student-athlete population, but at a lesser extent than the general population.

EmWave Research in Sport

Achieving coherence in sport is suggested to maximize focus, concentration, physical coordination, and emotional stability. The primary goal of EmWave™ research in sport has primarily been geared toward enhancing performance and encouraging athletes to be in the zone.[112] EmWave™ research in sport has been conducted with the sports of golf,[11] volleyball,[12] soccer,[13] basketball,[11] track and field,[13] and football. The use of EmWave™ technology in sport has shown decreased anxiety levels, stress, improved recovery and an improvement in sport performance after biofeedback training.[11,13]

Research using EmWave is minimal in student-athletes and has not focused primarily on the mental health, performance, and recovery of student-athletes as a focus for intervention benefits. Previous research has suggested EmWave technologies and interventions can be useful for decreasing symptoms of depression and anxiety, lowering perceived stress levels, and increasing sleep quality, recovery, and performance.[11,13] To date, EmWave research in sport has been conducted primarily through pilot studies, and only includes a few sport types (e.g., volleyball, track and field, soccer). [11-13] Future research should expand upon these studies and focus on mental health, performance, and recovery outcomes through interventions that include current student-athletes and multiple sport types.

Specific Aim 1. Examine and compare changes in psychological variables (e.g., depressive symptoms, level of activation, resilience, perceived stress) from pre-intervention to post-

intervention (4-weeks) for individuals across experimental groups (control and intervention).

Hypothesis 1.1. There will be a reduction in depressive symptoms, levels of activation, perceived stress, and an increase in resilience in the intervention group when compared to the control group.

Specific Aim 2. Examine changes in resilience across 4 weeks across experimental groups.

Hypothesis 2.1. There will be an increase in resilience in the intervention group when compared to the control group.

Specific Aim 3. Examine changes in baseline HRV coherence scores with a 4-week heart rhythm biofeedback training program across experimental groups.

Hypothesis 3.1. Baseline HRV coherence scores improve weekly with the 4-week heart rhythm biofeedback training program in the intervention group when compared to the control group.

Specific Aim 4. Examine changes in HRV coherence scores weekly, over a 4-week heart rhythm biofeedback training program across all experimental groups.

Hypothesis 4.1. HRV coherence scores will improve weekly with a 4-week heart rhythm biofeedback training program in the intervention group when compared to the control group.

Specific Aim 5. Examine and compare changes in sleep quality from pre-intervention, to post- intervention (4-weeks) for individuals across experimental groups (control and intervention).

Hypothesis 5.1. The 4-week heart rhythm biofeedback training program will improve sleep quality scores in the intervention group compared to the control group.

Specific Aim 6. Examine differences in daily performance scores for individuals across experimental groups (control and intervention).

Hypothesis 6.1. Individuals in the intervention group will report greater performance ratings compared to the control group.

Specific Aim 7: Compare performance ratings for individuals across experimental groups reported by student-athletes and coaches.

Hypothesis 7.1. The 4-week heart rhythm biofeedback training program will improve perceived performance scores for the intervention group when compared to the control group for student-athlete perceptions.

Specific Aim 8: Examine and compare changes in daily perceived recovery status scores for individuals across all experimental groups (control and intervention).

Hypothesis 8.1. The 4-week heart rhythm biofeedback training program will improve perceived recovery status scores in the intervention group, compared to the control group.

Methods

Research Design

We will utilize an experimental, randomized controlled design to examine the effects of a heart rate biofeedback training program on the dependent variables depressive symptoms, level of activation, sleep quality, perceived stress, sport performance, perceived recovery status, and coherence achievement scores. All participants will be randomized

into groups using a random number generator. Independent variables are the groups: intervention and control, and time points (pre-intervention and post-intervention). All participants will be pre-screened for inclusion and will then attend an information session to become accustomed to the Inner Balance™ application and procedures for the study. Dependent measures will be taken pre-intervention and post- intervention.

Participants

A convenient sample of participants (n = ~50) from local colleges and universities will be recruited to complete a 4-week heart rhythm biofeedback training program. To be included in the study participants must be current, NCAA or NAIA student-athletes, within the ages of 18 and 24. A specific exclusion criterion includes participants that report a chronic or acute injury in the health history questionnaire. This study will be approved by the Institutional Review Board at the University of South Carolina and participants will read and sign an approved Informed Consent Form prior to participation in the study.

Experimental Conditions

Control Group:

This control group will be composed of randomly selected participants. These participants will be free from any current injury during the 4-week intervention. Participants will be able to continue with the study if they are injured during the 4-week period. Participants in this control group will not receive the 4-week heart rate biofeedback intervention but will be asked to complete links from Qualtrics at 2 time points during the study (i.e., baseline, post-intervention) and provide perceived recovery status scores before practice and perceived performance scores after practice. Additionally, the control group

will be asked to wear the heart sensor earpiece for a baseline reading, and readings prior to and after team practice sessions.

Intervention Group:

This intervention group will be composed of randomly selected participants. These participants will be free from any current injury during the 4-week intervention. Participants will be able to continue with the study if they are injured during the 4-week period. The participants will receive the 4-week heart rate biofeedback intervention and will be asked to complete links from Qualtrics at 2 time points during the study (i.e., baseline, post-intervention) and provide perceived recovery status scores before practice and perceived performance scores after practice. Additionally, the intervention group will be asked to practice the self-regulation skills prior to and after team practice sessions for 3 to 5 minutes. While practicing their self-regulation skills, the participants will be asked to wear the heart rate sensor earpiece for a baseline reading, and readings prior to and after team practice sessions.

Randomization:

If the student-athletes consent to participate, they will be pre-screened to determine group eligibility, given a participant number, and will be placed into the experimental conditions. Once informed consent forms are turned in the research team will randomly place participants into the experimental groups with the use of a random number generator. This process will occur until the experimental groups are full.

Instruments and Protocols

Pre-Screening Questionnaire

Participants will be asked to provide some personal information (e.g., age, current and previous mental health status, injury status, sport, season of sport) to determine eligibility for the study.

Background Information Questionnaire

Personal information (e.g., age, sex, ethnicity, level of education, scholarship status) and self-reported anthropometric measurements (e.g., height, weight) will be collected from each student-athlete. The information will be used for basic demographics.

Psychosocial Measurements:

Center for Epidemiologic Studies Depression Scale Revised (CESD)

The Center for Epidemiologic Studies Depression Scale is a self-report measure of depressive symptoms. The scale measures 8 different subscales including: sadness, loss of interest, appetite, sleep, thinking/concentration, guilt, worthlessness, tired, fatigue, movement, suicidal ideation from the past week. Participants select how often during the past week they have felt or behaved on a scale of 1= rarely or none of the time to 4= most or all of the time. Scores higher than 16 on the CESD indicate a person at risk for depression. The internal consistency for the instrument is α= 0.85 to 0.90, with a test-retest reliability of α=0.45- 0.70.[21] (See Figure B.1)

Activation-Deactivation Adjective Check List (AD ACL)

The Activation-Deactivation Adjective Check List (AD ACL) is a multi-dimensional test of the arousal states, energetic and tense arousal. The AD ACL consists of 20 adjectives of Energy (general activation), Tiredness (deactivation-sleep), Tension

(high activation), and Calmness (general deactivation), the four subscales of the arousal states of energetic and tense arousal. The AD ACL instructs the individual to use the rating scale to describe their feelings at that moment, and to use their first reaction. The rating scale has four options to circle/mark. A selection of (vv) or double check means the individual *definitely* feels that mood or feeling at the moment, whereas a selection of (v) or single check means the individual *slightly* feels that mood or feeling at the moment. A selection of (?) or question mark means the word does not apply or the individual cannot decide if they feel that mood or feeling at the moment. If the individual selects no, that individual *definitely* is not feeling that mood or feeling at the moment. The intention of this instrument is for the individual to work through the items quickly and use their first reaction. The test-retest reliability for general activation is .89, high activation .93, general deactivation .79, and deactivation-sleep .89. (See Figure B.2)

Athlete Sleep Screening Questionnaire (ASSQ)

The Athlete Sleep Screening Questionnaire (ASSQ) is a sleep screening tool that was designed to detect sleep disturbances and daytime dysfunction in the athlete population. The ASSQ consists of 15 items that assess sleep quantity, sleep quality, insomnia and chronotype with a timeframe of "over the recent past." The sleep difficulty score (SDS) from the ASSQ is used to classify athletes into a level of sleep problems (none, mild, moderate, severe) based on the responses to 1,3,4,5, and 6. The cut off scores for each classification are as follows, none: 0-4, mild 5-7, moderate 8-10, and 11-17 severe. The modifiers for the ASSQ are not included in the SDS because they do not occur as frequently and are not always applicable. However, recommendations for better sleep

quality can be created from the modifiers. The ASSQ has an internal consistency of 0.74, and test-retest reliability of 0.86 for the athlete population. (See Figure B.3)

College Student Stress Scale (CSSS)

The College Student Stress Scale (CSSS) is an instrument designed to screen students experiencing distress during the transition to college life. The purpose of the instrument is to identify individuals who believe the transition to college is highly stressful. Specifically, the College Student Stress scale includes 11 items that are addressed with a 5-point scale to indicate how frequently they are distressed, anxious, or question their ability. The CSSS has good internal consistency and stability with an alpha for the total score of 0.87. (See Figure B.4)

Brief Resilience Scale (BRS)

The Brief Resilience Scale (BRS) is an instrument used to specifically assess the ability to bounce back from stress. This instrument instructs individuals to indicate the extent to which they agree with each of the 6 statements using a scale of 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree. The BRS has good internal consistency with a Cronbach alpha ranging from .80 to .91 and good test-retest reliability.[117] (See Figure B.5)

Performance Outcomes

Sport Performance

Participants will self-report their performance on a numeric rating scale (NRS) of 0-10 rating scale with 0 indicating worst performance and 10 indicating their best performance. This instrument will only be used after a home game/competition and an

away game/competition to compare perception of performance with and without the use of the Inner Balance™ techniques.

Sport Performance Rating Scale

Coaches will be asked to report the participants performance weekly on a numeric rating scale (NRS) with 0 indicating worst performance and 10 indicating their best performance compared to their typical performance. This instrument will be used once a week, weekly for 4 weeks.

Perceived Recovery Status Scale

The Perceived Recovery Status (PRS) Scale is a 0 to 10 scale created to assess an individual's recovery status (Figure B.5.6). The scale has varying levels of perceived recovery that is similar to a Rated Perceived Exertion scale.[118] The scale ranges from 0 (very poorly recovered) to 10 (very well recovered). Within the ratings of 0 to 3, a decline in performance would be expected, and between 4 and 7, a similar level of performance would be expected. With recovery ratings between levels 8 and 10, improved performance would be expected.[118] A PRS score will be obtained from participants at practice during the baseline HRV assessment. (Figure B.6)

Coherence Achievement Score

The coherence score will be obtained from the earpiece heartbeat sensor and graphed on the Inner Balance™ application. The heart rhythm biofeedback system will provide a low, medium, or high coherence score reflecting the participant's ability to balance the autonomic system. The coherence score will be gathered at each baseline, pre-practice, and post-practice. Participants will be able to export their coherence score directly from the application and email it to the researchers.

Manipulation Check

Participants will be asked to indicate how many times outside of the designated intervention practice sessions they utilized the self-regulation techniques during the week. This manipulation check will occur at the end of each week.

Experimental Procedures (Figure B.7)

Information Session and Prescreening

Interested participants will attend an informational session to meet with the researchers. During this session, the researchers will explain the nature and significance of the study and recruit potential participants. If the student-athletes consent to participate, they will be asked to fill out a survey prior to the information session to help determine group eligibility. The information that will be collected includes date of birth, age, injury status, sport, and season of their sport. Researchers will decode personal information, assign a participant number, and will randomly assign participants to either the control or intervention experimental condition. After participants are allocated to their respective groups, all participants will be emailed a Qualtrics link for the baseline survey.

Intervention

Participants in the intervention group will be asked to attend four intervention sessions, once a week, for 4 weeks. Each session is estimated to last 20 minutes. During each intervention session, HeartMath self-regulation techniques will be taught, reviewed, and practiced with the participants by an individual trained in the HeartMath techniques. The overall goal for self-regulation techniques is to help establish a new psychological baseline, resulting in sustainable perceptual and behavioral changes. During the first intervention session, participants will learn the Heart-Focused Breathing Technique™ and

the Quick Coherence Technique™. The following week, participants will learn the Heart Lock-In Technique™, and the Coherent Communication Technique™ in addition to reviewing the previous week's content. The third week will be the last week individuals will learn new concepts and techniques. The Freeze Frame Technique™ and Attitude Breathing Techniques™ will be learned in addition to reviewing previous techniques. The last week of the intervention will be used to review all the concepts learned. (See Appendix C). Each week, student-athletes will be asked to use the Inner Balance™ mobile application to practice the techniques learned during the intervention sessions. Prior to each practice the student-athlete will have a baseline heart rate reading with the Inner Balance™ sensor that clips onto their earlobe for 1 to 2 minutes and will report their perceived recovery. After a baseline is obtained, the student-athlete will be asked to practice the techniques learned for 3 to 5 minutes. This will again be repeated after practice. After each session, participants will be asked to report their perceived performance ratings and export their session output and email or message it to the researchers. For the duration of the 4 weeks, the participants will be asked to practice the techniques and engage in the coherence training before and after practice. Each week participants will be asked to complete the brief resilience scale and complete a manipulation check.

Statistical Analysis

SPSS statistical software (Version 26; SPSS Inc, Chicago, IL) will be used for all analyses. Descriptive statistics (mean and standard deviations) for all dependent variables will be calculated. Significance will be set at < 0.05 for all analyses. Power analyses, a priori, calculated a participant number of 60 to have adequate power, which is comparable to previously published studies examining heart rate biofeedback programs ranging from 14 to 60 participants.[11-13]

Aim 1.1. A 2 (Group: control**,** intervention) x 2 (Time: pre-intervention, post-intervention) ANOVA with repeated measures will be used to examine changes in psychological variables (e.g., depression, level of activation, perceived stress) from pre-intervention to end of the intervention.

Aim 1.2. A linear regression will be used to examine changes at week 0, 2, and 4.

Aim 2.1. A linear regression will be used to examine resilience changes across weeks 1,2,3,4.

Aim 3.1. A 2 (Group: control**,** intervention) x 4 (Week: Week 1, Week 2, Week 3, Week 4) ANOVA with repeated measures will be used to examine changes in baseline HRV coherence scores.

Aim 3.2. A linear regression will be used to examine changes in weekly HRV coherence scores for all four weeks.

Aim 4.1. A linear regression will be used to examine changes in weekly HRV coherence scores for both pre and post practice sessions for all four weeks.

Aim 5.1. A 2 (Group: control intervention) x 2 (Time: pre- intervention, end of intervention) ANOVA with repeated measures will be used to examine changes in sleep quality from pre-intervention to the end of the intervention.

Aim 5.2. A linear regression will be used to examine sleep quality changes at week 0, 2, and 4.

Aim 6.1. A linear regression will be used to examine daily performance scores.

Aim 7.1. A 2 (coach score, athlete average score) x 4 (Week: Week 1, Week 2, Week 3, Week 4) ANOVA will be used to compare performance scores between coaches and athletes over 4-weeks.

Aim 8.1. A linear regression will be used to examine daily perceived recovery scores.

References

1. National Alliance on Mental Illness; Depression. https://www.nami.org/Learn-More/Mental-Health-Conditions/Depression. Published 2015. Updated August 2017. Accessed January 30, 2019, 2019.
2. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.
3. Wolanin A, Hong E, Marks D, Panchoo K, Gross M. Prevalence of clinically elevated depressive symptoms in college athletes and differences by gender and sport. *Br J Sports Med.* 2016;50(3):167-171.
4. Institute NSS. Mental health best practices: Inter-association consensus document: best practices for understanding and supporting student-athlete mental wellness. 2016.

5. Breslin G, Shannon S, Haughey T, Donnelly P, Leavey G. A systematic review of interventions to increase awareness of mental health and well-being in athletes, coaches and officials. *Systematic reviews.* 2017;6(1):177.

6. Frank DL, Khorshid L, Kiffer JF, Moravec CS, McKee MG. Biofeedback in medicine: who, when, why and how? *Ment Health Fam Med.* 2010;7(2):85-91.

7. The Science of HeartMath. HeartMath. www.heartmath.com. Accessed2019.

8. Ratanasiripong P, Ratanasiripong N, Kathalae D. Biofeedback Intervention for Stress and Anxiety among Nursing Students: A Randomized Controlled Trial. *ISRN nursing.* 2012;2012:827972.

9. Ratanasiripong P, Sverduk K, Prince J, Hayashino D. Biofeedback and counseling for stress and anxiety among college students. *Journal of College Student Development.* 2012;53(5):742-749.

10. Whited A, Larkin KT, Whited M. Effectiveness of emWave biofeedback in improving heart rate variability reactivity to and recovery from stress. *Applied psychophysiology and biofeedback.* 2014;39(2):75-88.

11. Dziembowska I, Izdebski P, Rasmus A, Brudny J, Grzelczak M, Cysewski P. Effects of heart rate variability biofeedback on EEG alpha asymmetry and anxiety symptoms in male athletes: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(2):141-150.

12. Tanis CJ. Performance enhancement and stress reduction using biofeedback with women collegiate volleyball players. *Athletic Insight: The Online Journal of Sport Psychology.* 2012;4(2):127-140.

13. Rijken NH, Soer R, de Maar E, et al. Increasing performance of professional soccer players and elite track and field athletes with peak performance training and biofeedback: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(4):421-430.

14. Association AP. *Diagnostic and statistical manual of mental disorders (DSM-5®).* American Psychiatric Pub; 2013.

15. Uher R, Payne JL, Pavlova B, Perlis RH. Major depressive disorder in DSM-5: implications for clinical practice and research of changes from DSM-IV. *Depress Anxiety.* 2014;31(6):459-471.

16. Gotlib IH, LeMoult J. The "Ins" and "Outs" of the Depressive Disorders Section of DSM-5. *Clinical psychology: science and practice.* 2014;21(3):193-207.

17. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand.* 1983;67(6):361-370.

18. Lovibond S, Lovibond P. *Manual for the depression anxiety stress scales. 2nd edn. Sydney: Psychology Foundation, 1995.* ISBN 7334-1423-7330. http://www7332. psy. unsw. edu. au/groups/dass.

19. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Archives of general psychiatry.* 1961;4(6):561-571.

20. Beck AT, Steer RA, Carbin MG. Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review.* 1988;8(1):77-100.

21. Radloff LS. The CES-D scale: A self-report depression scale for research in the general population. *Applied psychological measurement.* 1977;1(3):385-401.

22. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *Journal of general internal medicine.* 2001;16(9):606-613.

23. Yang J, Peek-Asa C, Corlette J, Cheng G, Foster D, Albright J. Prevalence of and risk factors associated with symptoms of depression in competitive collegiate student athletes. *Clin J Sport Med.* 2007;17(6):481-487.

24. Li H, Moreland JJ, Peek-Asa C, Yang J. Preseason anxiety and depressive symptoms and prospective injury risk in collegiate athletes. *Am J Sports Med.* 2017;45(9):2148-2155.

25. Cox CE, Ross-Stewart L, Foltz BD. Investigating the Prevalence and Risk Factors of Depression Symptoms among NCAA Division I Collegiate Athletes. *J Sports Sci.* 2017;5:14-28.

26. Hammond T, Gialloreto C, Kubas H, Hap Davis Ht. The prevalence of failure-based depression among elite athletes. *Clin J Sport Med.* 2013;23(4):273-277.

27. Kumartasli M, Alp M, Yildiz E. Comparison of depression levels of elite wrestling and taekwondo athletes. *Turkish Journal of Sport and Exercise.* 2015;17(1):66-66.

28. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry.* 1961;4:561-571.

29. Keller J, Gomez R, Williams G, et al. HPA axis in major depression: cortisol, clinical symptomatology and genetic variation predict cognition. *Mol Psychiatry.* 2017;22(4):527-536.

30. Sue D, Sue DW, Sue S, Sue DM. *Understanding abnormal behavior.* Cengage Learning; 2015.

31. Saveanu RV, Nemeroff CB. Etiology of depression: genetic and environmental factors. *The Psychiatric clinics of North America.* 2012;35(1):51-71.

32. Gress-Smith JL, Roubinov DS, Andreotti C, Compas BE, Luecken LJ. Prevalence, severity and risk factors for depressive symptoms and insomnia in college undergraduates. *Stress and health : journal of the International Society for the Investigation of Stress.* 2015;31(1):63-70.

33. Liu Y, Zhang N, Bao G, et al. Predictors of depressive symptoms in college students: A systematic review and meta-analysis of cohort studies. *J Affect Disord.* 2019;244:196-208.

34. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.

35. Reardon CL, Hainline B, Aron CM, et al. Mental health in elite athletes: international olympic committee consensus statement (2019). *Br J Sports Med.* 2019;53(11):667-699.

36. Brewer B, Petrie T. *A comparison between injured and uninjured football players of selected psychosocial variables.* Vol 101995.

37. Leddy MH, Lambert MJ, Ogles BM. Psychological consequences of athletic injury among high-level competitors. *Research quarterly for exercise and sport.* 1994;65(4):347-354.

38. Appaneal RN, Levine BR, Perna FM, Roh JL. Measuring postinjury depression among male and female competitive athletes. *J Sport Exerc Psychol.* 2009;31(1):60-76.

39. Rice SM, Parker AG, Rosenbaum S, Bailey A, Mawren D, Purcell R. Sport-Related Concussion and Mental Health Outcomes in Elite Athletes: A Systematic Review. *Sports Med.* 2018;48(2):447-465.

40. Yrondi A, Brauge D, LeMen J, Arbus C, Pariente J. Depression and sports-related concussion: A systematic review. *Presse medicale (Paris, France : 1983).* 2017;46(10):890-902.

41. Roiger T, Weidauer L, Kern B. A longitudinal pilot study of depressive symptoms in concussed and injured/nonconcussed National Collegiate Athletic Association Division I student-athletes. *Journal of athletic training.* 2015;50(3):256-261.

42. Kerr ZY, Evenson KR, Rosamond WD, Mihalik JP, Guskiewicz KM, Marshall SW. Association between concussion and mental health in former collegiate athletes. *Injury epidemiology.* 2014;1(1):28.

43. Guskiewicz KM, Marshall SW, Bailes J, et al. Recurrent concussion and risk of depression in retired professional football players. *Medicine and science in sports and exercise.* 2007;39(6):903-909.

44. Broglio SP, Cantu RC, Gioia GA, et al. National Athletic Trainers' Association position statement: management of sport concussion. *Journal of athletic training.* 2014;49(2):245-265.

45. Weigand S, Cohen J, Merenstein D. Susceptibility for depression in current and retired student athletes. *Sports Health.* 2013;5(3):263-266.

46. Gehlert S, Song IH, Chang CH, Hartlage SA. The prevalence of premenstrual dysphoric disorder in a randomly selected group of urban and rural women. *Psychological medicine.* 2009;39(1):129-136.

47. Epperson CN, Steiner M, Hartlage SA, et al. Premenstrual dysphoric disorder: evidence for a new category for DSM-5. *Am J Psychiatry.* 2012;169(5):465-475.

48. Brody D PL, Hughes J. Prevalence of Depression Among Adults Aged 20 and Over: United States, 2013-2016. *NCHS Data Brief.* 2018.

49. Ibrahim AK, Kelly SJ, Adams CE, Glazebrook C. A systematic review of studies of depression prevalence in university students. *Psychiatry Res.* 2013;47(3):391-400.

50. Proctor SL, Boan-Lenzo C. Prevalence of depressive symptoms in male intercollegiate student-athletes and nonathletes. *J Clin Sport Psychol.* 2010;4(3):204-220.

51. Cox CE, Ross-Stewart L, Foltz BD. Investigating the Prevalence and Risk Factors of Depression Symptoms among NCAA Division I Collegiate Athletes. *J Sports Sci.* 2017;5:14-28.

52. Gorczynski PF, Coyle M, Gibson K. Depressive symptoms in high-performance athletes and non-athletes: a comparative meta-analysis. *Br J Sports Med.* 2017;51(18):1348-1354.

53. Spielberger C, Gorsuch R, Lushene P, Vagg P, Jacobs A. Manual for the State-Trait Anxiety Inventory (Form Y)(Consulting Psychologists, Palo Alto, CA). 1983.

54. Kogan CS, Stein DJ, Maj M, First MB, Emmelkamp PM, Reed GM. The Classification of Anxiety and Fear-Related Disorders in the ICD-11. *Depress Anxiety.* 2016;33(12):1141-1154.

55. Dell'Osso L, Abelli M, Pini S, et al. Dimensional assessment of DSM-5 social anxiety symptoms among university students and its relationship with functional impairment. *Neuropsychiatr Dis Treat.* 2014;10:1325-1332.

56. Regis JMO, Ramos-Cerqueira ATA, Lima MCP, Torres AR. Social anxiety symptoms and body image dissatisfaction in medical students: Prevalence and correlates. *Jornal Brasileiro de Psiquiatria.* 2018;67(2):65-73.

57. Asmundson GJ, Taylor S, Smits JA. Panic disorder and agoraphobia: an overview and commentary on DSM-5 changes. *Depress Anxiety.* 2014;31(6):480-486.

58. Stein MB, Sareen J. Generalized Anxiety Disorder. *New England Journal of Medicine.* 2015;373(21):2059-2068.

59. Spitzer RL, Kroenke K, Williams JB, Lowe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med.* 2006;166(10):1092-1097.

60. Beck AT, Epstein N, Brown G, Steer RA. An inventory for measuring clinical anxiety: psychometric properties. *Journal of consulting and clinical psychology.* 1988;56(6):893.

61. Zung WW. A rating instrument for anxiety disorders. *Psychosomatics: Journal of Consultation and Liaison Psychiatry.* 1971.

62. Ford JL, Ildefonso K, Jones ML, Arvinen-Barrow M. Sport-related anxiety: current insights. *Open access journal of sports medicine.* 2017;8:205-212.

63. Weinstein A, Maayan G, Weinstein Y. A study on the relationship between compulsive exercise, depression and anxiety. *J Behav Addict.* 2015;4(4):315-318.

64. Spielberger C. *State-Trait Anxiey Inventory: Bibliography.* 2nd ed. Palo Alto, CA: Consulting Psychologists Press; 1989.

65. Blanco C, Okuda M, Markowitz JC, Liu S-M, Grant BF, Hasin DS. The epidemiology of chronic major depressive disorder and dysthymic disorder: results from the National Epidemiologic Survey on Alcohol and Related Conditions. *The Journal of clinical psychiatry.* 2010;71(12):1645-1656.

66. Moreno-Peral P, Conejo-Ceron S, Motrico E, et al. Risk factors for the onset of panic and generalised anxiety disorders in the general adult population: a systematic review of cohort studies. *J Affect Disord.* 2014;168:337-348.

67. Blanco C, Rubio J, Wall M, Wang S, Jiu CJ, Kendler KS. Risk factors for anxiety disorders: common and specific effects in a national sample. *Depression and anxiety.* 2014;31(9):756-764.

68. Cheng SH, Sun ZJ, Lee IH, et al. Factors related to self-reported social anxiety symptoms among incoming university students. *Early intervention in psychiatry.* 2017;11(4):314-321.

69. Rice SM, Purcell R, De Silva S, Mawren D, McGorry PD, Parker AG. The Mental Health of Elite Athletes: A Narrative Systematic Review. *Sports Med.* 2016;46(9):1333-1353.

70. Hwang S, Choi Y. Data Mining in the Exploration of Stressors Among NCAA Student Athletes. *Psychol Rep.* 2016;119(3):787-803.

71. Kessler RC, Petukhova M, Sampson NA, Zaslavsky AM, Wittchen H-U. Twelve-month and lifetime prevalence and lifetime morbid risk of anxiety and mood disorders in the United States. *Int J Methods Psychiatr Res.* 2012;21(3):169-184.

72. Gulliver A, Griffiths KM, Mackinnon A, Batterham PJ, Stanimirovic R. The mental health of Australian elite athletes. *J Sci Med Sport.* 2015;18(3):255-261.

73. Schaal K, Tafflet M, Nassif H, et al. Psychological balance in high level athletes: gender-based differences and sport-specific patterns. *Plos one.* 2011;6(5):e19007.

74. Yang J, Cheng G, Zhang Y, Covassin T, Heiden EO, Peek-Asa C. Influence of symptoms of depression and anxiety on injury hazard among collegiate American football players. *Research in sports medicine.* 2014;22(2):147-160.

75. Klonsky ED, May AM, Saffer BY. Suicide, Suicide Attempts, and Suicidal Ideation. *Annu Rev Clin Psychol.* 2016;12:307-330.

76. Health NIoM. 2016 Suicide is a leading cause of death in the united states. Substance Abuse and Mental Health Services Administration. National Survey on Drug Use and Health Web site. Published 2017. Accessed.

77. Control NCfIPa. 10 Leading Causes of Death, United States. In. Prevention CfDCa, trans2017.

78. American College Health Association National College Health Assessment. American College Health Association. Accessed February 24, 2019.

79. Shim G, Jeong B. Predicting Suicidal Ideation in College Students with Mental Health Screening Questionnaires. *Psychiatry Investig.* 2018;15(11):1037-1045.

80. Nyer M, Mischoulon D, Alpert JE, et al. College students with depressive symptoms with and without fatigue: Differences in functioning, suicidality, anxiety, and depressive severity. *Ann Clin Psychiatry.* 2015;27(2):100-108.

81. Lamis DA, Ballard ED, May AM, Dvorak RD. Depressive Symptoms and Suicidal Ideation in College Students: The Mediating and Moderating Roles of

Hopelessness, Alcohol Problems, and Social Support. *J Clin Psychol.* 2016;72(9):919-932.

82. Becker SP, Dvorsky MR, Holdaway AS, Luebbe AM. Sleep problems and suicidal behaviors in college students. *J Psychiatr Res.* 2018;99:122-128.

83. Bentley KH, Franklin JC, Ribeiro JD, Kleiman EM, Fox KR, Nock MK. Anxiety and its disorders as risk factors for suicidal thoughts and behaviors: A meta-analytic review. *Clinical psychology review.* 2016;43:30-46.

84. Rao AL, Asif IM, Drezner JA, Toresdahl BG, Harmon KG. Suicide in National Collegiate Athletic Association (NCAA) Athletes: A 9-Year Analysis of the NCAA Resolutions Database. *Sports Health.* 2015;7(5):452-457.

85. Brown GT, Hainline B, Kroshus E, Wilfert M. Mind, body and sport: understanding and supporting student-athlete mental wellness. *Indianapolis, IN: National Collegiate Athletic Association.* 2014.

86. Gunn JF, Lester D. *Suicide in Professional and Amateur Athletes : Incidence, Risk Factors, and Prevention.* Springfield, Ill., U.S.A.: Charles C Thomas; 2013.

87. Reardon CL. Psychiatric Comorbidities in Sports. *Neurol Clin.* 2017;35(3):537-546.

88. Lester D. Participation in sports teams and suicidal behavior: an analysis of the 1995 national college health risk behavior survey. *Percept Mot Skills.* 2014;119(1):38-41.

89. Conley CS, Durlak JA, Dickson DA. An evaluative review of outcome research on universal mental health promotion and prevention programs for higher education students. *Journal of American College Health.* 2013;61(5):286-301.

90. Conley CS, Durlak JA, Kirsch AC. A Meta-analysis of universal mental health prevention programs for higher education students. *Prevention science : the official journal of the Society for Prevention Research.* 2015;16(4):487-507.

91. Conley CS, Durlak JA, Shapiro JB, Kirsch AC, Zahniser E. A Meta-Analysis of the Impact of Universal and Indicated Preventive Technology-Delivered Interventions for Higher Education Students. *Prevention science : the official journal of the Society for Prevention Research.* 2016;17(6):659-678.

92. Van Raalte JL, Cornelius AE, Andrews S, Diehl NS, Brewer BW. Mental Health Referral for Student-Athletes: Web-Based Education and Training. *Journal of Clinical Sport Psychology.* 2015;9(3):197-212.

93. Gulliver A, Griffiths KM, Christensen H, et al. Internet-based interventions to promote mental health help-seeking in elite athletes: an exploratory randomized controlled trial. *J Med Internet Res.* 2012;14(3):e69.

94. Reardon CL, Factor RM. Sport psychiatry. *Sports Medicine.* 2010;40(11):961-980.

95. Reardon CL. The sports psychiatrist and psychiatric medication. *International Review of Psychiatry.* 2016;28(6):606-613.

96. Wenzel A. Basic strategies of cognitive behavioral therapy. *The Psychiatric clinics of North America.* 2017;40(4):597-609.

97. Gustafsson H, Lundqvist C, Tod D. Cognitive behavioral intervention in sport psychology: A case illustration of the exposure method with an elite athlete. *Journal of Sport Psychology in Action.* 2017;8(3):152-162.

98. Goodman FR, Kashdan TB, Mallard TT, Schumann M. A brief mindfulness and yoga intervention with an entire NCAA Division I athletic team: An initial

investigation. *Psychology of Consciousness: Theory, Research, and Practice.* 2014;1(4):339-356.

99. Winzer R, Lindberg L, Guldbrandsson K, Sidorchuk A. Effects of mental health interventions for students in higher education are sustainable over time: a systematic review and meta-analysis of randomized controlled trials. *PeerJ.* 2018;6:e4598.

100. Regehr C, Glancy D, Pitts A. Interventions to reduce stress in university students: a review and meta-analysis. *J Affect Disord.* 2013;148(1):1-11.

101. Arnberg FK, Linton SJ, Hultcrantz M, Heintz E, Jonsson U. Internet-delivered psychological treatments for mood and anxiety disorders: a systematic review of their efficacy, safety, and cost-effectiveness. *PLoS One.* 2014;9(5):e98118.

102. Josephine K, Josefine L, Philipp D, David E, Harald B. Internet-and mobile-based depression interventions for people with diagnosed depression: a systematic review and meta-analysis. *Journal of affective disorders.* 2017;223:28-40.

103. Vázquez FL, Torres A, Blanco V, Díaz O, Otero P, Hermida E. Comparison of relaxation training with a cognitive-behavioural intervention for indicated prevention of depression in university students: A randomized controlled trial. *Journal of psychiatric research.* 2012;46(11):1456-1463.

104. Gipson CS, Chilton JM, Dickerson SS, Alfred D, Haas BK. Effects of a sleep hygiene text message intervention on sleep in college students. *J Am Coll Health.* 2019;67(1):32-41.

105. Trockel M, Manber R, Chang V, Thurston A, Taylor CB. An e-mail delivered CBT for sleep-health program for college students: effects on sleep quality and depression symptoms. *J Clin Sleep Med.* 2011;7(3):276-281.

106. Flett JAM, Hayne H, Riordan BC, Thompson LM, Conner TS. Mobile Mindfulness Meditation: a Randomised Controlled Trial of the Effect of Two Popular Apps on Mental Health. *Mindfulness.* 2019;10(5):863-876.

107. Palacios JE, Richards D, Palmer R, et al. Supported Internet-Delivered Cognitive Behavioral Therapy Programs for Depression, Anxiety, and Stress in University Students: Open, Non-Randomised Trial of Acceptability, Effectiveness, and Satisfaction. *JMIR mental health.* 2018;5(4):e11467.

108. Dvorakova K, Kishida M, Li J, et al. Promoting healthy transition to college through mindfulness training with first-year college students: Pilot randomized controlled trial. *J Am Coll Health.* 2017;65(4):259-267.

109. Hsu CJ, Meierbachtol A, George SZ, Chmielewski TL. Fear of Reinjury in Athletes. *Sports Health.* 2017;9(2):162-167.

110. Guo J, Yang J, Yi H, Singichetti B, Stavrinos D, Peek-Asa C. Differences in Postinjury Psychological Symptoms Between Collegiate Athletes With Concussions and Orthopedic Injuries. *Clin J Sport Med.* 2018.

111. Psychophysiological Assessment. In: Schmidt RF, Willis WD, eds. *Encyclopedia of Pain.* Berlin, Heidelberg: Springer Berlin Heidelberg; 2007:2059-2059.

112. Jimenez Morgan S, Molina Mora JA. Effect of Heart Rate Variability Biofeedback on Sport Performance, a Systematic Review. *Applied psychophysiology and biofeedback.* 2017;42(3):235-245.

113. Panadero E. A Review of Self-regulated Learning: Six Models and Four Directions for Research. *Frontiers in psychology.* 2017;8:422-422.

114. McCraty R, Zayas MA. Cardiac coherence, self-regulation, autonomic stability, and psychosocial well-being. *Frontiers in psychology.* 2014;5:1090-1090.

115. Kim H-G, Cheon E-J, Bai D-S, Lee YH, Koo B-H. Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. *Psychiatry Investig.* 2018;15(3):235-245.

116. Thurber M, McCraty R., Kabaker, B., Sawyer, S. . *HeartMath interventions program for health professionals: Establishing a new baseline for sustained behavioral change.* HeartMath LLC: HeartMath LLC; 2008, 2017.

117. Smith BW, Dalen J, Wiggins K, Tooley E, Christopher P, Bernard J. The brief resilience scale: assessing the ability to bounce back. *Int J Behav Med.* 2008;15(3):194-200.

118. Laurent CM, Green JM, Bishop PA, et al. A practical approach to monitoring recovery: development of a perceived recovery status scale. *Journal of strength and conditioning research / National Strength & Conditioning Association.* 2011;25(3):620-628.

Bibliography

1. National Alliance on Mental Illness; Depression. https://www.nami.org/Learn-More/Mental-Health-Conditions/Depression. Published 2015. Updated August 2017. Accessed January 30, 2019, 2019.
2. Proctor SL, Boan-Lenzo C. Prevalence of depressive symptoms in male intercollegiate student-athletes and nonathletes. *J Clin Sport Psychol.* 2010;4(3):204-220.
3. Yang J, Peek-Asa C, Corlette J, Cheng G, Foster D, Albright J. Prevalence of and risk factors associated with symptoms of depression in competitive collegiate student athletes. *Clin J Sport Med.* 2007;17(6):481-487.
4. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.
5. Wolanin A, Hong E, Marks D, Panchoo K, Gross M. Prevalence of clinically elevated depressive symptoms in college athletes and differences by gender and sport. *Br J Sports Med.* 2016;50(3):167-171.
6. Martignetti A, Arthur-Cameselle J, Keeler L, Chalmers G. The relationship between burnout and depression in intercollegiate athletes: An examination of gender and sport-type. *Journal for the Study of Sports and Athletes in Education.* 2020;14(2):100-122. 7. Pluhar E, McCracken C, Griffith KL, Christino MA, Sugimoto D, Meehan WP, 3rd. Team sport athletes may be less likely to suffer

anxiety or depression than individual sport athletes. *J Sci Med Sport.* 2019;18(3):490-496.

8. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.
9. Wolanin A, Hong E, Marks D, Panchoo K, Gross M. Prevalence of clinically elevated depressive symptoms in college athletes and differences by gender and sport. *Br J Sports Med.* 2016;50(3):167-171.
10. Li H, Moreland JJ, Peek-Asa C, Yang J. Preseason anxiety and depressive symptoms and prospective injury risk in collegiate athletes. *Am J Sports Med.* 2017;45(9):2148-2155.
11. Institute NSS. Mental health best practices: Inter-association consensus document: best practices for understanding and supporting student-athlete mental wellness. 2016.
12. Breslin G, Shannon S, Haughey T, Donnelly P, Leavey G. A systematic review of interventions to increase awareness of mental health and well-being in athletes, coaches and officials. *Systematic reviews.* 2017;6(1):177.
13. Frank DL, Khorshid L, Kiffer JF, Moravec CS, McKee MG. Biofeedback in medicine: who, when, why and how? *Ment Health Fam Med.* 2010;7(2):85-91.
14. The Science of HeartMath. HeartMath. www.heartmath.com. Accessed2019.
15. Ratanasiripong P, Ratanasiripong N, Kathalae D. Biofeedback Intervention for Stress and Anxiety among Nursing Students: A Randomized Controlled Trial. *ISRN nursing.* 2012;2012:827972.

16. Ratanasiripong P, Sverduk K, Prince J, Hayashino D. Biofeedback and counseling for stress and anxiety among college students. *Journal of College Student Development.* 2012;53(5):742-749.

17. Whited A, Larkin KT, Whited M. Effectiveness of emWave biofeedback in improving heart rate variability reactivity to and recovery from stress. *Applied psychophysiology and biofeedback.* 2014;39(2):75-88.

18. Dziembowska I, Izdebski P, Rasmus A, Brudny J, Grzelczak M, Cysewski P. Effects of heart rate variability biofeedback on EEG alpha asymmetry and anxiety symptoms in male athletes: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(2):141-150.

19. Tanis CJ. Performance enhancement and stress reduction using biofeedback with women collegiate volleyball players. *Athletic Insight: The Online Journal of Sport Psychology.* 2012;4(2):127-140.

20. Rijken NH, Soer R, de Maar E, et al. Increasing performance of professional soccer players and elite track and field athletes with peak performance training and biofeedback: a pilot study. *Appl Psychophysiol Biofeedback.* 2016;41(4):421-430.

21. Anxiety Disorder. National Institute of Mental Health. https://www.nimh.nih.gov/health/statistics/any-anxiety-disorder.shtml. Published 2017. Updated November 2017. Accessed February 19, 2019.

22. National Alliance on Mental Illness; Depression. Published 2015. Updated March 2015. Accessed January 30, 2019.

23. American College Health Association National College Health Assessment. American College Health Association. Accessed February 24, 2019.

24. Kessler RC, Wang PS. The descriptive epidemiology of commonly occurring mental disorders in the United States. *Annu Rev Public Health.* 2008;29:115-129.

25. Ibrahim AK, Kelly SJ, Adams CE, Glazebrook C. A systematic review of studies of depression prevalence in university students. *Psychiatry Res.* 2013;47(3):391-400.

26. Cox CE, Ross-Stewart L, Foltz BD. Investigating the prevalence and risk factors of depression symptoms among NCAA division I collegiate athletes. *J Sports Sci.* 2017;5:14-28.

27. Spielberger C. *State-Trait Anxiey Inventory: Bibliography.* 2nd ed. Palo Alto, CA: Consulting Psychologists Press; 1989.

28. Horikawa M, Yagi A. The relationships among trait anxiety, state anxiety and the goal performance of penalty shoot-out by university soccer players. *PLoS One.* 2012;7(4):e35727.

29. Armstrong S, Oomen-Early J. Social connectedness, self-esteem, and depression symptomatology among collegiate athletes versus nonathletes. *J Am Coll Health.* 2009;57(5):521-526.

30. Sundgot-Borgen J. Nutrient intake of female elite athletes suffering from eating disorders. *Int J Sport Nutr.* 1993;3(4):431-442.

31. Radloff LS. The CES-D scale: A self-report depression scale for research in the general population. *Applied psychological measurement.* 1977;1(3):385-401.

32. Radloff LS. The use of the center for epidemiologic studies depression scale in adolescents and young adults. *J Youth Adolesc.* 1991;20(2):149-166.

33. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1(3):385-401.

34. Spielberger C, Gorsuch R, Lushene P, Vagg P, Jacobs A. Manual for the State-Trait Anxiety Inventory (Form Y)(Consulting Psychologists, Palo Alto, CA). 1983.

35. Rosenberg M. Society and the adolescent self-concept. In: Princeton, NJ: Princeton University Press; 1965.

36. Rosenberg M. Rosenberg self-esteem scale (RSE). *Acceptance and commitment therapy Measures package.* 1965;61(52):18.

37. Faul F, Erdfelder E, Lang A-G, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods.* 2007;39(2):175-191.

38. Faul F, Erdfelder E, Buchner A, Lang A-G. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods.* 2009;41(4):1149-1160.

39. Reardon CL, Hainline B, Aron CM, et al. Mental health in elite athletes: international olympic committee consensus statement (2019). *Br J Sports Med.* 2019;53(11):667-699.

40. Hale B, Koch K, Raglin J. State anxiety responses to 60 minutes of cross training. *Br J Sports Med.* 2002;36(2):105-107.

41. Ford JL, Ildefonso K, Jones ML, Arvinen-Barrow M. Sport-related anxiety: current insights. *Open access journal of sports medicine.* 2017;8:205-212.

42. Koivula N, Hassmén P, Fallby J. Self-esteem and perfectionism in elite athletes: effects on competitive anxiety and self-confidence. *Personality and individual differences.* 2002;32(5):865-875.

43. Acharya Pandey R, Chalise HN. Self-esteem and academic stress among nursing students. *Kathmandu Univ Med J (KUMJ).* 2015;13(52):298-302.

44. Engel SG, Johnson C, Powers PS, et al. Predictors of disordered eating in a sample of elite division I college athletes. *Eat Behav.* 2003;4(4):333-343.

45. Jimenez Morgan S, Molina Mora JA. Effect of Heart Rate Variability Biofeedback on Sport Performance, a Systematic Review. *Appl Psychophysiol Biofeedback.* 2017;42(3):235-245.

46. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Archives of general psychiatry.* 1961;4(6):561-571.

47. Laborde S, Mosley E, Thayer JF. Heart rate variability and cardiac vagal tone in psychophysiological research - recommendations for experiment planning, data analysis, and data reporting. *Front Psychol.* 2017;8:213-213.

48. Dong J-G. The role of heart rate variability in sports physiology. *Exp Ther Med.* 2016;11(5):1531-1536.

49. Brown GT, Hainline B, Kroshus E, Wilfert M. Mind, body and sport: understanding and supporting student-athlete mental wellness. *Indianapolis, IN: National Collegiate Athletic Association.* 2014.

50. Van Raalte JL, Cornelius AE, Andrews S, Diehl NS, Brewer BW. Mental health referral for student-athletes: web-based education and training. *J Clin Sport Psychol.* 2015;9(3):197-212.

51. Gulliver A, Griffiths KM, Christensen H, et al. Internet-based interventions to promote mental health help-seeking in elite athletes: an exploratory randomized controlled trial. *J Med Internet Res.* 2012;14(3):e69.

52. Nédélec M, Halson S, Abaidia A-E, Ahmaidi S, Dupont G. Stress, sleep and recovery in elite soccer: a critical review of the literature. *Sports Med.* 2015;45(10):1387-1400.

53. Kellmann M, Bertollo M, Bosquet L, et al. Recovery and performance in sport: consensus statement. *Int J Sports Physiol Perform.* 2018;13(2):240-245.

54. Watson AM. Sleep and athletic performance. *Curr Sports Med Rep.* 2017;16(6):413-418.

55. Shaffer F, Ginsberg J. An overview of heart rate variability metrics and norms. *Front Public Health.* 2017;5:258.

56. Shaffer F, Venner J. Heart rate variability anatomy and physiology. *Biofeedback.* 2013;41:13-25.

57. McCraty R, Shaffer F. Heart rate variability: new perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health risk. *Glob Adv Health Med.* 2015;4(1):46-61.

58. Castaneda D, Esparza A, Ghamari M, Soltanpur C, Nazeran H. A review on wearable photoplethysmography sensors and their potential future applications in health care. *Int j biosens.* 2018;4(4):195-202.

59. Tanis CJ. The effects of heart rhythm variability biofeedback with emotional regulation on the athletic performance of women collegiate volleyball players. *Psychology.* 2011.

60. Jiménez S, Molina JAM. Effect of heart rate variability biofeedback on sport performance, a systematic review. *Appl Psychophysiol Biofeedback.* 2017;42(3):235-245.

61. Thurber M, McCraty R, Kabaker B, Shaffer T, Wilson B, Sawyer S. HeartMath interventions for counselors, therapists, social workers and health care professionals: establishing a new baseline for sustained behavioral change. *Boulder Creek, CA: HeartMath LLC.* 2008.

62. Thayer RE. Activation-deactivation adjective check list: current overview and structural analysis. *Psychol Rep.* 1986;58(2):607-614.

63. Thayer RE. Factor analytic and reliability studies on the activation-deactivation adjective check list. *Psychol Rep.* 1978;42(3):747-756.

64. Feldt RC. Development of a brief measure of college stress: the college student stress scale. *Psychol Rep.* 2008;102(3):855-860.

65. Smith BW, Dalen J, Wiggins K, Tooley E, Christopher P, Bernard J. The brief resilience scale: assessing the ability to bounce back. *Int J Behav Med.* 2008;15(3):194-200.

66. Laurent CM, Green JM, Bishop PA, et al. A practical approach to monitoring recovery: development of a perceived recovery status scale. *J Strength Cond Res.* 2011;25(3):620-628.

67. Hjermstad MJ, Fayers PM, Haugen DF, et al. Studies comparing numerical rating scales, verbal rating scales, and visual analogue scales for assessment of pain intensity in adults: a systematic literature review. *J Pain Symptom Manage.* 2011;41(6):1073-1093.

68. Bender AM, Lawson D, Werthner P, Samuels CH. The clinical validation of the athlete sleep screening questionnaire: an instrument to identify athletes that need further sleep assessment. *Sports Med Open.* 2018;4(1):23.

69. Pitney WA. Strategies for establishing trustworthiness in qualitative research. *Int J Athl Ther Train.* 2004;9(1):26-28.

70. Hill CE. Consensual qualitative research (CQR): methods for conducting psychotherapy research. In: *Psychother Res.* Springer; 2015:485-499.

71. Hill CE, Knox S, Thompson BJ, Williams EN, Hess SA, Ladany N. Consensual qualitative research: an update. *J Couns Psychol.* 2005;52(2):196.

72. Deschodt-Arsac V, Lalanne R, Spiluttini B, Bertin C, Arsac LM. Effects of heart rate variability biofeedback training in athletes exposed to stress of university examinations. *PLoS One.* 2018;13(7):e0201388.

73. Ratanasiripong P, Ratanasiripong N, Kathalae D. Biofeedback intervention for stress and anxiety among nursing students: a randomized controlled trial. *ISRN Nurs.* 2012:827-972.

74. Whited A, Larkin K, Whited M. Effectiveness of emwave biofeedback in improving heart rate variability reactivity to and recovery from stress. *Appl Psychophysiol Biofeedback.* 2014;39.

75. Litwic-Kaminska K, Izdebski P. Resiliency against stress among athletes. *Health Psychol Rep.* 2016;4:79-90.

76. Association AP. *Diagnostic and statistical manual of mental disorders (DSM-5®).* American Psychiatric Pub; 2013.

77. Uher R, Payne JL, Pavlova B, Perlis RH. Major depressive disorder in DSM-5: implications for clinical practice and research of changes from DSM-IV. *Depress Anxiety.* 2014;31(6):459-471.

78. Gotlib IH, LeMoult J. The "Ins" and "Outs" of the Depressive Disorders Section of DSM-5. *Clinical psychology: science and practice.* 2014;21(3):193-207.

79. Zigmond AS, Snaith RP. The hospital anxiety and depression scale. *Acta Psychiatr Scand.* 1983;67(6):361-370.

80. Lovibond S, Lovibond P. *Manual for the depression anxiety stress scales. 2nd edn. Sydney: Psychology Foundation, 1995.* ISBN 7334-1423-7330. http://www7332. psy. unsw. edu. au/groups/dass.

81. Beck AT, Steer RA, Carbin MG. Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review.* 1988;8(1):77-100.

82. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *Journal of general internal medicine.* 2001;16(9):606-613.

83. Cox CE, Ross-Stewart L, Foltz BD. Investigating the Prevalence and Risk Factors of Depression Symptoms among NCAA Division I Collegiate Athletes. *J Sports Sci.* 2017;5:14-28.

84. Hammond T, Gialloreto C, Kubas H, Hap Davis Ht. The prevalence of failure-based depression among elite athletes. *Clin J Sport Med.* 2013;23(4):273-277.

85. Kumartasli M, Alp M, Yildiz E. Comparison of depression levels of elite wrestling and taekwondo athletes. *Turkish Journal of Sport and Exercise.* 2015;17(1):66-66.

86. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry.* 1961;4:561-571.

87. Keller J, Gomez R, Williams G, et al. HPA axis in major depression: cortisol, clinical symptomatology and genetic variation predict cognition. *Mol Psychiatry.* 2017;22(4):527-536.

88. Sue D, Sue DW, Sue S, Sue DM. *Understanding abnormal behavior.* Cengage Learning; 2015.

89. Saveanu RV, Nemeroff CB. Etiology of depression: genetic and environmental factors. *The Psychiatric clinics of North America.* 2012;35(1):51-71.

90. Gress-Smith JL, Roubinov DS, Andreotti C, Compas BE, Luecken LJ. Prevalence, severity and risk factors for depressive symptoms and insomnia in college undergraduates. *Stress and health : journal of the International Society for the Investigation of Stress.* 2015;31(1):63-70.

91. Liu Y, Zhang N, Bao G, et al. Predictors of depressive symptoms in college students: A systematic review and meta-analysis of cohort studies. *J Affect Disord.* 2019;244:196-208.

92. Wolanin A, Gross M, Hong E. Depression in athletes: prevalence and risk factors. *Curr Sports Med Rep.* 2015;14(1):56-60.

93. Brewer B, Petrie T. *A comparison between injured and uninjured football players of selected psychosocial variables.* Vol 101995.

94. Leddy MH, Lambert MJ, Ogles BM. Psychological consequences of athletic injury among high-level competitors. *Research quarterly for exercise and sport.* 1994;65(4):347-354.

95. Appaneal RN, Levine BR, Perna FM, Roh JL. Measuring postinjury depression among male and female competitive athletes. *J Sport Exerc Psychol.* 2009;31(1):60-76.

96. Rice SM, Parker AG, Rosenbaum S, Bailey A, Mawren D, Purcell R. Sport-Related Concussion and Mental Health Outcomes in Elite Athletes: A Systematic Review. *Sports Med.* 2018;48(2):447-465.

97. Yrondi A, Brauge D, LeMen J, Arbus C, Pariente J. Depression and sports-related concussion: A systematic review. *Presse medicale (Paris, France : 1983).* 2017;46(10):890-902.

98. Roiger T, Weidauer L, Kern B. A longitudinal pilot study of depressive symptoms in concussed and injured/nonconcussed National Collegiate Athletic Association Division I student-athletes. *Journal of athletic training.* 2015;50(3):256-261.

99. Kerr ZY, Evenson KR, Rosamond WD, Mihalik JP, Guskiewicz KM, Marshall SW. Association between concussion and mental health in former collegiate athletes. *Injury epidemiology.* 2014;1(1):28.

100. Guskiewicz KM, Marshall SW, Bailes J, et al. Recurrent concussion and risk of depression in retired professional football players. *Medicine and science in sports and exercise.* 2007;39(6):903-909.

101. Broglio SP, Cantu RC, Gioia GA, et al. National Athletic Trainers' Association position statement: management of sport concussion. *Journal of athletic training.* 2014;49(2):245-265.

102. Weigand S, Cohen J, Merenstein D. Susceptibility for depression in current and retired student athletes. *Sports Health.* 2013;5(3):263-266.

103. Gehlert S, Song IH, Chang CH, Hartlage SA. The prevalence of premenstrual dysphoric disorder in a randomly selected group of urban and rural women. *Psychological medicine.* 2009;39(1):129-136.

104. Epperson CN, Steiner M, Hartlage SA, et al. Premenstrual dysphoric disorder: evidence for a new category for DSM-5. *Am J Psychiatry.* 2012;169(5):465-475.

105. Brody D PL, Hughes J. Prevalence of Depression Among Adults Aged 20 and Over: United States, 2013-2016. *NCHS Data Brief.* 2018.

106. Cox CE, Ross-Stewart L, Foltz BD. Investigating the Prevalence and Risk Factors of Depression Symptoms among NCAA Division I Collegiate Athletes. *J Sports Sci.* 2017;5:14-28.

107. Gorczynski PF, Coyle M, Gibson K. Depressive symptoms in high-performance athletes and non-athletes: a comparative meta-analysis. *Br J Sports Med.* 2017;51(18):1348-1354.

108. Kogan CS, Stein DJ, Maj M, First MB, Emmelkamp PM, Reed GM. The Classification of Anxiety and Fear-Related Disorders in the ICD-11. *Depress Anxiety.* 2016;33(12):1141-1154.

109. Dell'Osso L, Abelli M, Pini S, et al. Dimensional assessment of DSM-5 social anxiety symptoms among university students and its relationship with functional impairment. *Neuropsychiatr Dis Treat.* 2014;10:1325-1332.

110. Regis JMO, Ramos-Cerqueira ATA, Lima MCP, Torres AR. Social anxiety symptoms and body image dissatisfaction in medical students: Prevalence and correlates. *Jornal Brasileiro de Psiquiatria.* 2018;67(2):65-73.

111. Asmundson GJ, Taylor S, Smits JA. Panic disorder and agoraphobia: an overview and commentary on DSM-5 changes. *Depress Anxiety.* 2014;31(6):480-486.

112. Stein MB, Sareen J. Generalized Anxiety Disorder. *New England Journal of Medicine.* 2015;373(21):2059-2068.

113. Spitzer RL, Kroenke K, Williams JB, Lowe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med.* 2006;166(10):1092-1097.

114. Beck AT, Epstein N, Brown G, Steer RA. An inventory for measuring clinical anxiety: psychometric properties. *Journal of consulting and clinical psychology.* 1988;56(6):893.

115. Zung WW. A rating instrument for anxiety disorders. *Psychosomatics: Journal of Consultation and Liaison Psychiatry.* 1971.

116. Weinstein A, Maayan G, Weinstein Y. A study on the relationship between compulsive exercise, depression and anxiety. *J Behav Addict.* 2015;4(4):315-318.

117. Blanco C, Okuda M, Markowitz JC, Liu S-M, Grant BF, Hasin DS. The epidemiology of chronic major depressive disorder and dysthymic disorder: results from the National Epidemiologic Survey on Alcohol and Related Conditions. *The Journal of clinical psychiatry.* 2010;71(12):1645-1656.

118. Moreno-Peral P, Conejo-Ceron S, Motrico E, et al. Risk factors for the onset of panic and generalised anxiety disorders in the general adult population: a systematic review of cohort studies. *J Affect Disord.* 2014;168:337-348.

119. Blanco C, Rubio J, Wall M, Wang S, Jiu CJ, Kendler KS. Risk factors for anxiety disorders: common and specific effects in a national sample. *Depression and anxiety.* 2014;31(9):756-764.

120. Cheng SH, Sun ZJ, Lee IH, et al. Factors related to self-reported social anxiety symptoms among incoming university students. *Early intervention in psychiatry.* 2017;11(4):314-321.

121. Rice SM, Purcell R, De Silva S, Mawren D, McGorry PD, Parker AG. The Mental Health of Elite Athletes: A Narrative Systematic Review. *Sports Med.* 2016;46(9):1333-1353.

122. Hwang S, Choi Y. Data Mining in the Exploration of Stressors Among NCAA Student Athletes. *Psychol Rep.* 2016;119(3):787-803.

123. Kessler RC, Petukhova M, Sampson NA, Zaslavsky AM, Wittchen H-U. Twelve-month and lifetime prevalence and lifetime morbid risk of anxiety and mood disorders in the United States. *Int J Methods Psychiatr Res.* 2012;21(3):169-184.

124. Gulliver A, Griffiths KM, Mackinnon A, Batterham PJ, Stanimirovic R. The mental health of Australian elite athletes. *J Sci Med Sport.* 2015;18(3):255-261.

125. Schaal K, Tafflet M, Nassif H, et al. Psychological balance in high level athletes: gender-based differences and sport-specific patterns. *Plos one.* 2011;6(5):e19007.

126. Yang J, Cheng G, Zhang Y, Covassin T, Heiden EO, Peek-Asa C. Influence of symptoms of depression and anxiety on injury hazard among collegiate American football players. *Research in sports medicine.* 2014;22(2):147-160.

127. Klonsky ED, May AM, Saffer BY. Suicide, Suicide Attempts, and Suicidal Ideation. *Annu Rev Clin Psychol.* 2016;12:307-330.

128. Health NIoM. 2016 Suicide is a leading cause of death in the united states. Substance Abuse and Mental Health Services Administration. National Survey on Drug Use and Health Web site. Published 2017. Accessed.

129. Control NCfIPa. 10 Leading Causes of Death, United States. In. Prevention CfDCa, trans2017.

130. Shim G, Jeong B. Predicting Suicidal Ideation in College Students with Mental Health Screening Questionnaires. *Psychiatry Investig.* 2018;15(11):1037-1045.

131. Nyer M, Mischoulon D, Alpert JE, et al. College students with depressive symptoms with and without fatigue: Differences in functioning, suicidality, anxiety, and depressive severity. *Ann Clin Psychiatry.* 2015;27(2):100-108.

132. Lamis DA, Ballard ED, May AM, Dvorak RD. Depressive Symptoms and Suicidal Ideation in College Students: The Mediating and Moderating Roles of Hopelessness, Alcohol Problems, and Social Support. *J Clin Psychol.* 2016;72(9):919-932.

133. Becker SP, Dvorsky MR, Holdaway AS, Luebbe AM. Sleep problems and suicidal behaviors in college students. *J Psychiatr Res.* 2018;99:122-128.

134. Bentley KH, Franklin JC, Ribeiro JD, Kleiman EM, Fox KR, Nock MK. Anxiety and its disorders as risk factors for suicidal thoughts and behaviors: A meta-analytic review. *Clinical psychology review.* 2016;43:30-46.

135. Rao AL, Asif IM, Drezner JA, Toresdahl BG, Harmon KG. Suicide in National Collegiate Athletic Association (NCAA) Athletes: A 9-Year Analysis of the NCAA Resolutions Database. *Sports Health.* 2015;7(5):452-457.

136. Gunn JF, Lester D. *Suicide in Professional and Amateur Athletes : Incidence, Risk Factors, and Prevention.* Springfield, Ill., U.S.A.: Charles C Thomas; 2013.

137. Reardon CL. Psychiatric Comorbidities in Sports. *Neurol Clin.* 2017;35(3):537-546.

138. Lester D. Participation in sports teams and suicidal behavior: an analysis of the 1995 national college health risk behavior survey. *Percept Mot Skills.* 2014;119(1):38-41.

139. Conley CS, Durlak JA, Dickson DA. An evaluative review of outcome research on universal mental health promotion and prevention programs for higher education students. *Journal of American College Health.* 2013;61(5):286-301.

140. Conley CS, Durlak JA, Kirsch AC. A Meta-analysis of universal mental health prevention programs for higher education students. *Prevention science : the official journal of the Society for Prevention Research.* 2015;16(4):487-507.

141. Conley CS, Durlak JA, Shapiro JB, Kirsch AC, Zahniser E. A Meta-Analysis of the Impact of Universal and Indicated Preventive Technology-Delivered Interventions for Higher Education Students. *Prevention science : the official journal of the Society for Prevention Research.* 2016;17(6):659-678.

142. Van Raalte JL, Cornelius AE, Andrews S, Diehl NS, Brewer BW. Mental Health Referral for Student-Athletes: Web-Based Education and Training. *Journal of Clinical Sport Psychology.* 2015;9(3):197-212.

143. Reardon CL, Factor RM. Sport psychiatry. *Sports Medicine.* 2010;40(11):961-980.

144. Reardon CL. The sports psychiatrist and psychiatric medication. *International Review of Psychiatry.* 2016;28(6):606-613.

145. Wenzel A. Basic strategies of cognitive behavioral therapy. *The Psychiatric clinics of North America.* 2017;40(4):597-609.

146. Gustafsson H, Lundqvist C, Tod D. Cognitive behavioral intervention in sport psychology: A case illustration of the exposure method with an elite athlete. *Journal of Sport Psychology in Action.* 2017;8(3):152-162.

147. Goodman FR, Kashdan TB, Mallard TT, Schumann M. A brief mindfulness and yoga intervention with an entire NCAA Division I athletic team: An initial investigation. *Psychology of Consciousness: Theory, Research, and Practice.* 2014;1(4):339-356.

148. Winzer R, Lindberg L, Guldbrandsson K, Sidorchuk A. Effects of mental health interventions for students in higher education are sustainable over time: a systematic review and meta-analysis of randomized controlled trials. *PeerJ.* 2018;6:e4598.

149. Regehr C, Glancy D, Pitts A. Interventions to reduce stress in university students: a review and meta-analysis. *J Affect Disord.* 2013;148(1):1-11.

150. Arnberg FK, Linton SJ, Hultcrantz M, Heintz E, Jonsson U. Internet-delivered psychological treatments for mood and anxiety disorders: a systematic review of their efficacy, safety, and cost-effectiveness. *PLoS One.* 2014;9(5):e98118.

151. Josephine K, Josefine L, Philipp D, David E, Harald B. Internet-and mobile-based depression interventions for people with diagnosed depression: a systematic review and meta-analysis. *Journal of affective disorders.* 2017;223:28-40.

152. Vázquez FL, Torres A, Blanco V, Díaz O, Otero P, Hermida E. Comparison of relaxation training with a cognitive-behavioural intervention for indicated

prevention of depression in university students: A randomized controlled trial. *Journal of psychiatric research.* 2012;46(11):1456-1463.

153. Gipson CS, Chilton JM, Dickerson SS, Alfred D, Haas BK. Effects of a sleep hygiene text message intervention on sleep in college students. *J Am Coll Health.* 2019;67(1):32-41.

154. Trockel M, Manber R, Chang V, Thurston A, Taylor CB. An e-mail delivered CBT for sleep-health program for college students: effects on sleep quality and depression symptoms. *J Clin Sleep Med.* 2011;7(3):276-281.

155. Flett JAM, Hayne H, Riordan BC, Thompson LM, Conner TS. Mobile Mindfulness Meditation: a Randomised Controlled Trial of the Effect of Two Popular Apps on Mental Health. *Mindfulness.* 2019;10(5):863-876.

156. Palacios JE, Richards D, Palmer R, et al. Supported Internet-Delivered Cognitive Behavioral Therapy Programs for Depression, Anxiety, and Stress in University Students: Open, Non-Randomised Trial of Acceptability, Effectiveness, and Satisfaction. *JMIR mental health.* 2018;5(4):e11467.

157. Dvorakova K, Kishida M, Li J, et al. Promoting healthy transition to college through mindfulness training with first-year college students: Pilot randomized controlled trial. *J Am Coll Health.* 2017;65(4):259-267.

158. Hsu CJ, Meierbachtol A, George SZ, Chmielewski TL. Fear of Reinjury in Athletes. *Sports Health.* 2017;9(2):162-167.

159. Guo J, Yang J, Yi H, Singichetti B, Stavrinos D, Peek-Asa C. Differences in Postinjury Psychological Symptoms Between Collegiate Athletes With Concussions and Orthopedic Injuries. *Clin J Sport Med.* 2018.

160. Psychophysiological Assessment. In: Schmidt RF, Willis WD, eds. *Encyclopedia of Pain.* Berlin, Heidelberg: Springer Berlin Heidelberg; 2007:2059-2059.

161. Panadero E. A Review of Self-regulated Learning: Six Models and Four Directions for Research. *Frontiers in psychology.* 2017;8:422-422.

162. McCraty R, Zayas MA. Cardiac coherence, self-regulation, autonomic stability, and psychosocial well-being. *Frontiers in psychology.* 2014;5:1090-1090.

163. Kim H-G, Cheon E-J, Bai D-S, Lee YH, Koo B-H. Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. *Psychiatry Investig.* 2018;15(3):235-245.

164. Thurber M, McCraty R., Kabaker, B., Sawyer, S. . *HeartMath interventions program for health professionals: Establishing a new baseline for sustained behavioral change.* HeartMath LLC: HeartMath LLC; 2008, 2017.

165. Laurent CM, Green JM, Bishop PA, et al. A practical approach to monitoring recovery: development of a perceived recovery status scale. *Journal of strength and conditioning research / National Strength & Conditioning Association.* 2011;25(3):620-628.

Appendix A

Informed Consent Form

UNIVERSITY OF SOUTH CAROLINA

OFFICE OF RESEARCH COMPLIANCE

INSTITUTIONAL REVIEW BOARD FOR HUMAN RESEARCH
APPROVAL LETTER

Samantha Weber
Education
Physical Education
Columbia, SC 29208

Re: **Pro00092702**

Dear Ms. Samantha Weber:

This is to certify that the following proposal entitled, ***Effects of a Heart Rate Biofeedback Training Program on Mental Health Outcomes in Collegiate Student-Athletes,*** was reviewed and approved by the University of South Carolina Institutional Review Board (USC IRB) on **11/1/2019** by **Expedited** review (category **4 and 7**).

When applicable, approved consent /assent documents are located under the "Stamped ICF" tab on the Study Workspace in eIRB.

PRINCIPAL INVESTIGATORS ARE TO ADHERE TO THE FOLLOWING APPROVAL CONDITIONS

- The research must be conducted according to the proposal/protocol that was approved by the USC IRB
- Changes to the procedures, recruitment materials, or consent documents, must be approved by the USC IRB prior to implementation
- *If applicable*, each subject should receive a copy of the approved date stamped consent document
- It is the responsibility of the principal investigator to report promptly to the USC IRB the following:
  - Unanticipated problems and/or unexpected risks to subjects
  - Adverse events effecting the rights or welfare of any human subject participating in the research study
- Research records, including signed consent documents, must be retained for at least (3) three years after the termination of the last IRB approval
- No subjects may be involved in any research study procedure prior to the IRB approval date

The Office of Research Compliance is an administrative office that supports the University of South Carolina Institutional Review Board. If you have questions, contact Lisa M. Johnson at lisaj@mailbox.sc.edu or (803) 777-6670.

Sincerely,

Lisa M. Johnson
ORC Assistant Director and IRB Manager

Appendix B

Instruments

Center for Epidemiologic Studies Depression Scale (CESD)

Below is a list of the ways you might have felt or behaved. Please tell me how often you have felt this way during the past week.

1 = Rarely or None of the Time (Less than 1 Day)
2 = Some or a Little of the Time (1-2 Days)
3 = Occasionally or a Moderate Amount of Time (3-4 Days)
4 = Most or All of the Time (5-7 Days)

During the past week:

	Rarely or none of the time (less than 1 day)	**Some or a little of the time** (1-2 days)	**Occasionally or a moderate amount of time** (3-4 days)	**Most or all of the time** (5-7 days)
1. I was bothered by things that usually don't bother me.	□	□	□	□
2. I did not feel like eating; my appetite was poor.	□	□	□	□
3. I felt that I could not shake off the blues even with help from my family or friends.	□	□	□	□
4. I felt that I was just as good as other people.	□	□	□	□
5. I had trouble keeping my mind on what I was doing.	□	□	□	□
6. I felt depressed.	□	□	□	□
7. I felt that everything I did was an effort.	□	□	□	□
8. I felt hopeful about the future.	□	□	□	□
9. I thought my life had been a failure.	□	□	□	□
10. I felt fearful.	□	□	□	□
11. My sleep was restless.	□	□	□	□
12. I was happy.	□	□	□	□
13. I talked less than usual.	□	□	□	□
14. I felt lonely.	□	□	□	□
15. People were unfriendly.	□	□	□	□
16. I enjoyed life.	□	□	□	□
17. I had crying spells.	□	□	□	□
18. I felt sad.	□	□	□	□
19. I felt that people dislike me.	□	□	□	□
20. I could not get "going".	□	□	□	□

Figure B.1 Center for Epidemiologic Studies Depression Scale

✓✓		*definitely feel*		
✓		*feel slightly*		
?		*cannot decide*		
no		*definitely do not feel*		
Check list:				
Active	✓✓	✓	?	no
Placid	✓✓	✓	?	no
Sleepy	✓✓	✓	?	no
Jittery	✓✓	✓	?	no
Energetic	✓✓	✓	?	no
Intense	✓✓	✓	?	no
Calm	✓✓	✓	?	no
Tired	✓✓	✓	?	no
Vigorous	✓✓	✓	?	no
At-rest	✓✓	✓	?	no
Drowsy	✓✓	✓	?	no
Fearful	✓✓	✓	?	no
Lively	✓✓	✓	?	no
Still	✓✓	✓	?	no
Wide-awake	✓✓	✓	?	no
Clutched-up	✓✓	✓	?	no
Quiet	✓✓	✓	?	no
Full-of-pep	✓✓	✓	?	no
Tense	✓✓	✓	?	no
Wakeful	✓✓	✓	?	no

Instructions to the user: Each of the words describes feelings or mood. Please use the rating scale next to each word to describe your feelings at this moment.

Figure B.2 Activation-Deactivation Adjective Check List

Athlete Sleep Screening Questionnaire (ASSQ)

INSTRUCTIONS

The following questions relate to your sleep habits. Please circle the best answer which you think represents your typical sleep habits over the recent past. For all questions, circle a letter from 'a' to 'e' unless otherwise specified.

1. During the recent past, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)
   a. 5 to 6 hours
   b. 6 to 7 hours
   c. 7 to 8 hours
   d. 8 to 9 hours
   e. more than 9 hours

2. How many naps per week do you take?
   a. none
   b. once or twice
   c. three or four times
   d. five to seven times

3. How satisfied/dissatisfied are you with the quality of your sleep?
   a. very satisfied
   b. somewhat satisfied
   c. neither satisfied nor dissatisfied
   d. somewhat dissatisfied
   e. very dissatisfied

4. During the recent past, how long has it usually taken you to fall asleep each night?
   a. 15 minutes or less
   b. 16 – 30 minutes
   c. 31 – 60 minutes
   d. longer than 60 minutes

5. How often do you have trouble staying asleep?
   a. none
   b. once or twice per week
   c. three or four times per week
   d. five to seven days per week

Figure B.3 Athlete Sleep Screening Questionnaire

6. During the recent past, how often have you taken medicine to help you sleep (prescribed or over-the-counter)?
   a. none
   b. once or twice per week
   c. three or four times per week
   d. five to seven times per week

7. Considering only your own "feeling best" rhythm, at what time would you get up if you were entirely free to plan your day?
   a. 5:00 am – 6:30 am
   b. 6:30 am – 7:45 am
   c. 7:45 am – 9:45 am
   d. 9:45 am – 11:00 am
   e. 11:00 am – 12:00 pm (noon)

8. How alert do you feel during the first half-hour after having awakened?
   a. not at all alert
   b. slightly alert
   c. fairly alert
   d. very alert

9. Do you consider yourself to be a morning type person or an evening type person?
   a. definitely a morning type
   b. more a morning type than an evening type
   c. more an evening type than a morning type
   d. definitely an evening type

10. Considering your own "feeling best" rhythm, at what time would you go to bed if you were entirely free to plan your evening?
   a. 8:00 pm – 9:00 pm
   b. 9:00 pm – 10:15 pm
   c. 10:15 pm – 12:30 am
   d. 12:30 am – 1:45 am
   e. 1:45 am – 3:00 am

11. When you are travelling for your sport, do you experience sleep disturbance?
   a. Yes
   b. No

12. When you are travelling for your sport, do you experience daytime dysfunction (feeling generally unwell or having poor performance)?
   a. Yes
   b. No

Figure B.3 Athlete Sleep Screening Questionnaire

13. Are you typically a loud snorer?
    a. Yes
    b. No

14. Have you been told that you choke, gasp, or stop breathing for periods of time during sleep?
    a. Yes
    b. No

15. On average, how many caffeinated products (caffeine pills, coffee, tea, soda, energy drinks) do you have per day? For coffee and tea, one drink = 6-8oz/177-237ml; for caffeinated soda, one drink = 1 can (12oz/355ml)?
    a. Less than 1 per day
    b. 1-2 per day
    c. 3 per day
    d. 4 per day
    e. 5 or more per day

16. Over the recent past, how often do you use an electronic device (example: cell phone, computer, tablet, T.V. etc.) within 1 hour of going to bed?
    a. Not at all
    b. 1-3 times per week
    c. 4-6 times per week
    d. Every day

Figure B.3 Athlete Sleep Screening Questionnaire

College Student Stress Scale (CSSS)

For the following items, report how often each has occurred this semester using the following scale:

Never	Rarely	Sometimes	Often	Very Often
1	2	3	4	5

1. Felt anxious or distressed about personal relationships _____
2. Felt anxious or distressed about family matters _____
3. Felt anxious or distressed about financial matters _____
4. Felt anxious or distressed about academic matters _____
5. Felt anxious or distressed about housing matters _____
6. Felt anxious or distressed about being away from home _____
7. Questioned your ability to handle difficulties in your life _____
8. Questioned your ability to attain your personal goals _____
9. Felt anxious or distressed because events were not going as planned _____
10. Felt as though you were NO longer in control of your life _____
11. Felt overwhelmed by difficulties in your life _____

Figure B.4 College Student Stress Scale

Brief Resilience Scale (BRS)

	Please respond to each item by marking one box per row	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
BRS 1	I tend to bounce back quickly after hard times	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
BRS 2	I have a hard time making it through stressful events.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
BRS 3	It does not take me long to recover from a stressful event.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
BRS 4	It is hard for me to snap back when something bad happens.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1
BRS 5	I usually come through difficult times with little trouble.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
BRS 6	I tend to take a long time to get over set-backs in my life.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1

Scoring: Add the responses varying from 1-5 for all six items giving a range from 6-30. Divide the total sum by the total number of questions answered.

My score: _____ item average / 6

Figure B.5 Brief Resilience Scale

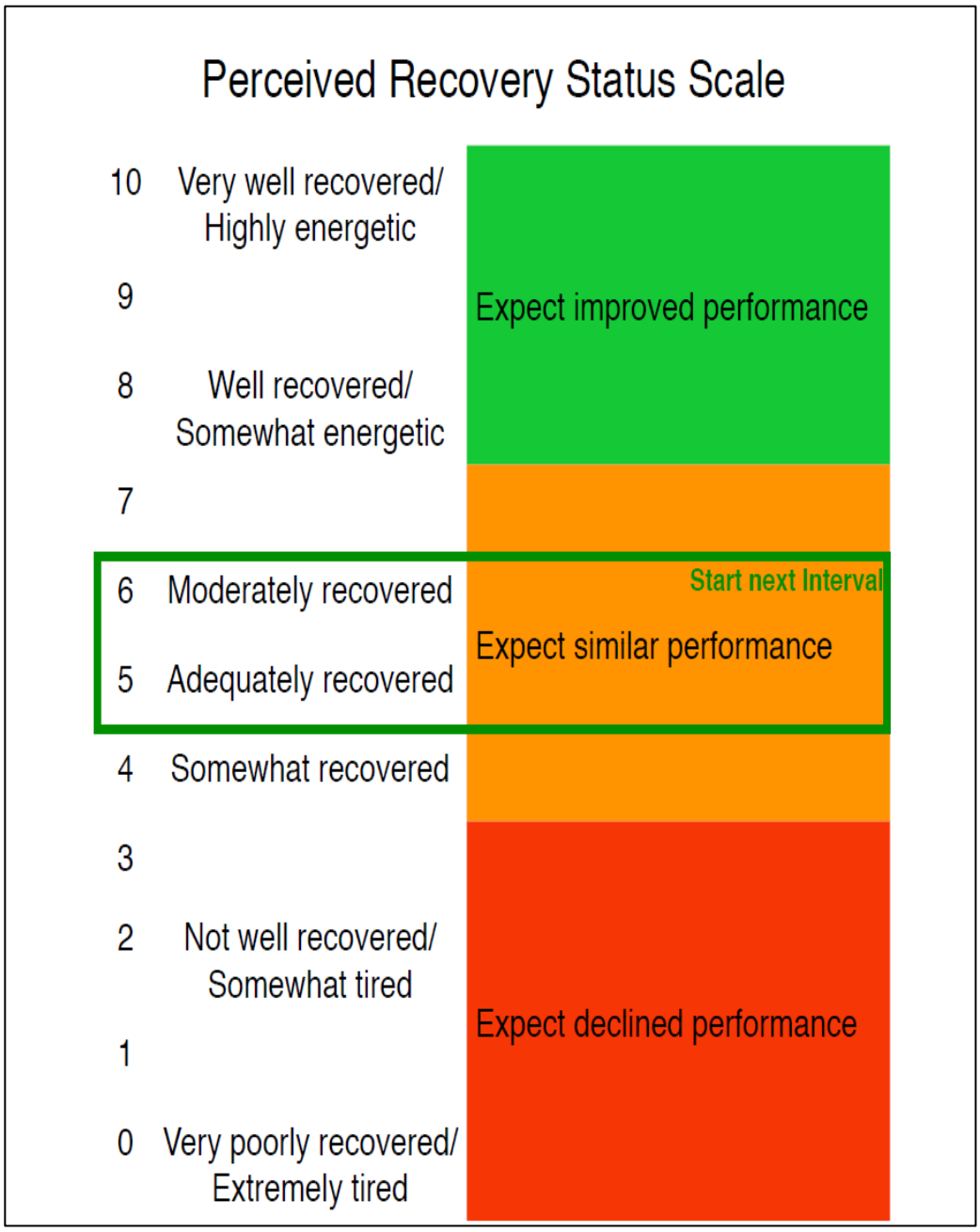

Figure B.6 Perceived Recovery Status Scale

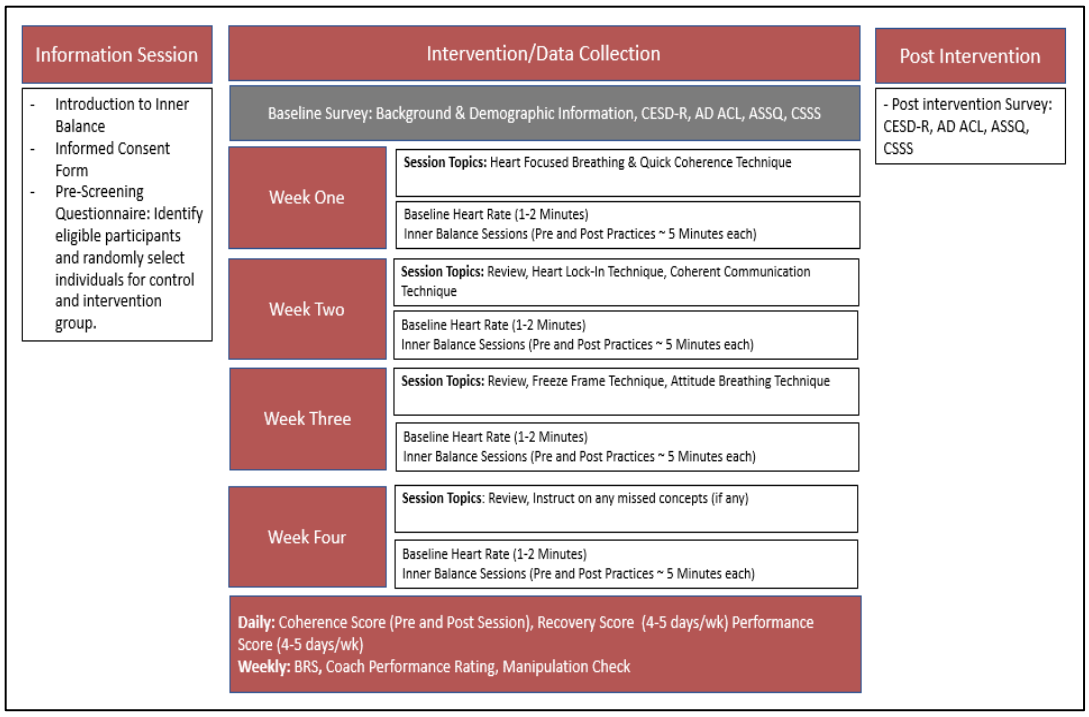

Figure B.7 Data collection flow chart.

Abbreviations: Center for Epidemiologic Studies Revised (CESD-R), Activation-Deactivation Adjective Check List (AD ACL), Athlete Sleep Screening Questionnaire (ASSQ), College Student Stress Scale (CSSS), Brief Resilience Scale (BRS)

Appendix C

Intervention Protocol

Week 1 Intervention Session:

Heart-Focused Breathing Technique:

1. Think of Heart-Focused Breathing as a form of a neutral, time-out zone where you can step back, neutralize your emotions and see more options with clarity.
2. Heart-Focused Breathing Technique stops the impact of stress on the mind and body and eliminates energy drain.
3. **Step:** "Focus your attention in the area of the heart. Imagine your breath is flowing in and out of your heart or chest area, breathing a little slower and deeper than usual."

Quick Coherence Technique:

1. Quick Coherence Technique is most effective with engagement of positive feelings, where an individual is replacing depleting emotions with ones to renew your system.
2. **Step 1:** Focus attention in the area of the heart. Imagine your breath is flowing in and out of your heart or chest area, breathing a little slower and deeper than usual.
3. **Step 2:** Make a sincere attempt to experience a regenerative feeling such as appreciation or care for someone or something in your life.

Week 2 Intervention Session:

Heart Lock-In Technique:

1. **Step 1:** Focus your attention in the area of the heart. Imagine your breath is flowing in and out of your heart or chest area, breathing a little slower and deeper than usual.
2. **Step 2:** Activate a regenerative feeling such as appreciation, care or compassion.
3. **Step 3:** Radiate that renewing feeling to yourself and others.

Coherent Communication Technique:

1. This technique is designed to create connection and understanding between a listener and a speaker.
2. **Step 1:** Shift into a heart-coherent state before communicating to effectively share and receive information.
3. **Step 2:** Listen for the essence of what is being said without prejudging or getting pulled into drama before the communication is complete.
4. Speak from a genuine tone and consider what you are going to say and how it may affect others.
5. **Step 3:** During important or sensitive communications its effective to confirm the essence of what you herd to insure mutual understanding.

Week 3 Intervention Session:

Attitude Breathing Technique:

1. **Step 1:** Recognize a feeling or attitude that you want to change and identify a replacement attitude.
2. **Step 2:** Focus your attention in the area of the heart. Imagine your breath is flowing in and out of your heart or chest area, breathing a little slower and deeper than usual.

3. **Step 3:** Breathe the feeling of the new attitude slowly and casually through your heart area.
    a. The replacement attitude can be obvious, but it takes the breathing and feeling of a new attitude for the shift to occur.

Freeze Frame Technique:

1. This technique gives you an opportunity to find and sort out solutions and increase options to resolve problems and conflicts. The technique gives you a chance to find more efficient options and resolve problems that may be depleting your energy.
2. **Step 1:** Acknowledge the problem or issue and any attitudes or feelings about it.
3. **Step 2:** Focus your attention in the area of the heart. Imagine your breath is flowing in and out of your heart or chest area, breathing a little slower and deeper than usual.
4. **Step 3:** Make a sincere attempt to experience a regenerative feeling such as appreciation or care for someone or something in your life.
5. **Step 4:** From this more objective place, ask yourself what would be a more efficient or effective attitude, action or solution.
6. **Step 5:** Quietly observe any subtle changes in perceptions, attitudes or feelings. Commit to sustaining beneficial attitude shifts and acting on new insights.